THE physical therapy REVIEW

38th Annual Conference
American Physical Therapy Association
The Palmer House Chicago, Illinois
July 2-7, 1961

40th ANNIVERSARY

A Review of Skeletal Muscle — HARRISON

A Review of Sensory Receptors in Skeletal Muscles with Special Emphasis on the Muscle Spindle — HARRISON

A Review of the Motor Unit — HARRISON

Case Reports — DAVIS

Suggestions from the Field — BARBERO and MACHEK

Volume 41, Number 1 **January 1961**

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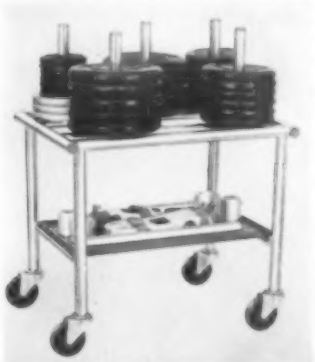

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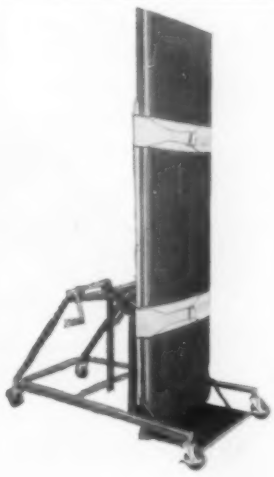

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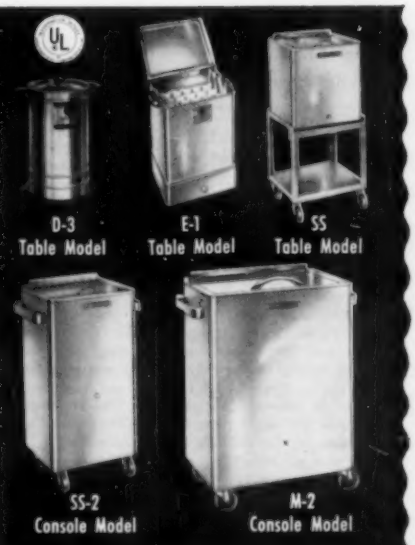

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January 1961
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Published monthly by the American Physical Therapy Association, 1790 Broadway, New York 19, N. Y. *Change of address:* Notice should include old as well as new address and should state whether or not change is permanent. *Subscription rates:* $7.00 per year to non-members; $8.00 in Canada and foreign countries.

Scientific Articles

A Review of Skeletal Muscle—Virginia F. Harrison, Ph.D. 17

A Review of Sensory Receptors in Skeletal Muscles with Special Emphasis on the Muscle Spindle—Virginia F. Harrison, Ph.D. 25

A Review of the Motor Unit—Virginia F. Harrison, Ph.D. 30

Case Reports

Case Report of a Quadruple Amputee—Barbara A. Davis 41

Suggestions from the Field

Two Temporary Braces for Adults—James W. Barbero and Otaker Machek, M.D. 44

Regular Features

American Physical Therapy Association:
Officers, Standing and Advisory Committees 8
Chapter Presidents 10
Annual Reports (September 1960 *Review*, page 673)
Chapter Directory (November 1960 *Review*, page 838)

State Board Examinations—1961 12

Editorial 46

Letters 48

Association News 49
Obituary 49
Report of the Nominating Committee 49
Marriages 50
Chapter News 50
New Student Members 51

Conference—1961 52

Education 57
Short Term Courses 57
Guide to Graduate Education 59
Schools Offering Courses in Physical Therapy (December 1960 *Review*, page 895)

Index to Current Literature 56

Abstracts 61

Book Reviews 69

What's New 75

Positions Available 76

Index to Advertisers 80

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The Physical Therapy Review

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VOLUME 41 JANUARY 1961 NUMBER 1

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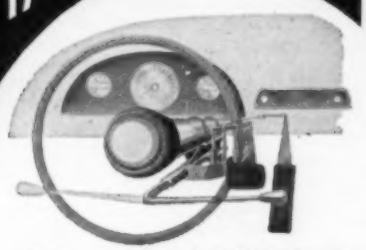

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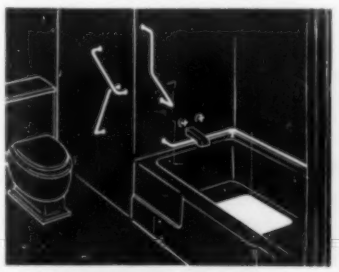

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Since he hasn't done anything much except shuffle his graphs and clear his throat whenever I brought the matter up, I've decided to go back to the old style for a while. I can think of a number of reasons to justify it... but I suppose a *big* reason is that I sort of get a kick out of writing it.

So, for the next few months anyway, you won't see our page full of great claims and gorgeously retouched photographs. Instead, I'll try to pass along our observations on the world around us. I have a sneaking suspicion that it might be more interesting than just another page of "stuffy" advertising ... and I hope you think so too. Any comments? Our mailman has a strong back!

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A Review of Skeletal Muscle

Virginia F. Harrison, Ph.D.*

Gross Structure

Muscles are made up largely of muscle fibers and connective tissue. The whole muscle is covered by connective tissue (the epimysium), which consists of collagen, reticular and elastic fibers, and fat cells. The connective tissue surrounding small bundles of parallel muscle fibers (fasciculi) is the perimysium; and that which surrounds the individual fibers is the endomysium. The connective tissue throughout the muscle forms a harness so that the pull exerted by the muscle fibers may be applied effectively. The muscle is attached to other structures by connective tissue or is continuous as in a sphincter.

The myotendon junction is apparently formed by a blending of epimysium, perimysium, and endomysium with the collagenous bundles of the tendon. Christensen[1] found that in mature muscle there is a distinct boundary between the fiber and its attachment to the tendon, whereas in the developing muscle the myofibrils run directly into the elementary fibril of the tendon. The sarcolemma over the cone-shaped end of the muscle fiber appears to fuse with the endomysium.[2]

The arrangement of the fasciculi in relation to the tendon is variable. Fasciculi may run parallel or nearly parallel to the long axis of the muscle, producing a spindle or fusiform shape. Fasciculi that are parallel to one another, but oblique to the tendon of the muscle, form a uni- or bi-penniform shape. Fasciculi that converge on the several sides of the tendon form a multi-penniform muscle. Fasciculi that converge from a broad surface to a narrow tendinous point form a radial pattern. Many other patterns exist. Since most muscles are four or five times as thick as their tendon, the only way by which these muscle fibers can attach to the tendon without change in direction is by meeting the tendon at an angle.[3]

Arteries and veins course through the epimysium; arterioles and venules pass through the perimysium; and capillaries supply the endomysium. Lymphatic vessels are present in the epimysium and perimysium, but not in the endomysium of striated muscle.[4] Nerves enter the muscle near the main arterial branch and then divide, distributing motor and sensory fibers.

Microscopic Structure

1. The Shape of the Muscle Fiber

The length of striated muscle fibers in the human varies from one millimeter (stapedius muscle[5, 6]) to 34 centimeters (sartorius muscle). The length is somewhat less in muscles concerned with finer movement. The diameter is usually given as 10–100 microns; however, Christensen[1] reports individual fibers measuring up to 150 microns in diameter in the thigh and gluteal muscles. The ends of the muscle fibers are variable in shape: some are tapering and conical, others are bluntly rounded, truncated or split.[1]

Wohlfart[7, 8] describes two types of muscle fibers in the human designated as A and B. The B muscle fibers are those that develop earlier, embryonically, and are larger in diameter during the first months of life. About one or two B fibers occur per smallest (primary) bundle. During the first four postnatal months (Fig. 1), these fibers have a cross-sectional area of 280–420 microns,[2] whereas the A fibers have a cross-sectional area of 30–140 microns.[2] The B fibers are usually centrally located in the primary bundles. The significance of these large fibers is not known. Wohlfart believes that the B fibers might be those he has observed which are more resistant

* Department of Military Medicine and Surgery, Medical Field Service School, Brooke Army Medical Center, Fort Sam Houston, Texas.

This study was supported by a grant from the Wisconsin Alumni Research Foundation.

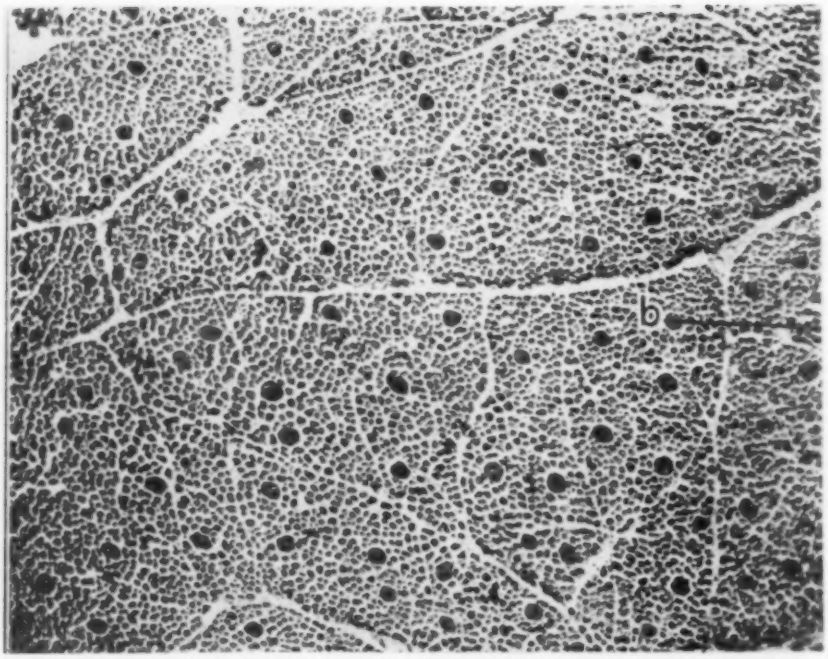

FIG. 1. Section from the sartorius muscle of a 4-month-old child, showing a normal picture. The B fibers (b) are readily visible. Haggqvists's iron hematoxylin stain; x 80 (Wohlfart, G. Ueber das Vorkommen veischie dener arten von Muskelfasern in der Skelettmuskulatur. *Acta Psychiatric et Neurologica* Supp., 12:1-119, 1937).

to disease of neurogenic origin and that possibly these fibers play a role in muscle tonus.[9]

The smallest bundles of muscle fibers are called bundles of the first order or primary bundles. For example, several of the primary bundles form a bundle of the second order; and several of the second order form a bundle of the third order, and so on. The number of muscle fibers in a primary bundle varies extensively in the same and different muscles. In a primary bundle the number of muscle fibers may range from 10–300.[7] Feinstein, Lindegård, Nyman, and Wohlfart[10] isolated fasciculi 1–2 millimeters (mm.) in diameter. Denny-Brown and Pennybacker[11] isolated muscle fasciculi which measured from 2–12 mm. in diameter.

The length of muscle fibers varies within a bundle. Feinstein *et al.*[10] found that all the muscle fibers in the first dorsal interosseus of the hand, first lumbrical of the hand, tibialis anterior, and medial head of the gastrocnemius extended throughout the length of the bundles. The bundles were usually less than 5 centimeters (cm.) long, except in the tibialis anterior where some bundles were 7–8 cm. in length. Christensen[1] found that the muscle fibers of the biceps brachii extended throughout the length of the muscle, except in the distal part of the short head. Feinstein *et al.*[10] found that most of the fibers of the brachioradialis muscle extended throughout the length of the muscle; some extended from the proximal tendon to the middle of the belly, and others from the middle of the muscle to the distal tendon. Jarcho, Eyzaguirre, Berman, and Lilienthal[12] found that muscle fibers terminated at irregular intervals throughout the muscle in the anterior gracilis of the adult rat.

2. The Sarcolemma

The muscle fiber is enclosed by a double membrane, the sarcolemma, which is considered a part of the muscle fiber. However, the sarcolemma separates more readily from the sarcoplasm than from the endomysium when the fiber is immersed in hot water. Bennett[13] states that in the mouse the sarcolemma is approximately 100 Å. (Ång-

strom*) in diameter. Each layer is about 40 Å. wide with a space of about 20 Å. between.

3. The Nuclei

A striated muscle fiber is multinucleated with several hundred nuclei in fibers which are several centimeters long. The nuclei, in the mature fiber, are located near the periphery. These nuclei vary in shape from oval to round.

4. The Cytoplasm

The cytoplasm contains muscle glycogen, fat granules, reticulum, myofibrils, lipoprotein granules, and sarcoplasm. Fibers rich in sarcoplasm have a dark appearance in the fresh state and are called dark fibers or red muscle, whereas those that are poor in sarcoplasm are called light or white fibers. Adams, Denny-Brown, and Pearson[14] state that the color of a muscle fiber is dependent on its content of myoglobin and cytochrome. Red muscle is less distinctly striated than the white muscle. Copenhaver and Johnson[5] state that red muscle is less irritable than white muscle and gives a slower contraction, but it can maintain contraction for a longer period than white fibers. Human muscle is thought to be a mixture of red and white fibers.

The striation of the muscle fibers is produced by a repetitive variation in the density of the protein. This striation stops about one micron short of the terminal cone of the sarcolemma. The striation of the whole muscle fiber results from the anatomic arrangement of its component parts. These details will be described in relation to the myofibril.

5. The Myofibril

Each muscle fiber contains approximately 5–36 myofibrils. They are a comparatively rigid constituent of the cytoplasm and are the site of the contractile process. The myofibrils are about a micron in diameter.[15] Perry[16] states that the chemical content of the myofibril is myosin, tropomyosin, actin, and actomyosin. The myofibril contains myofilaments, particles of Palade, and interstitial material.

Myofibrils are usually arranged parallel to each other within the muscle fiber. Sometimes the myofibrils are patterned in a spiral fashion. Wohlfart[17, 7] has noted that approximately one per cent of the extrinsic muscles of the eye are made up of fibers with myofibrils and that these fibers occur almost exclusively in the region of the nerve entry. Krüger[18] has also noted two distinct patterns of myofibrils in humans and other mammals: one pattern he terms "fibril structure," and the other pattern "field structure." He thinks the muscle fibers with field structure myofibrils are concerned with muscle tonus.

The myofibril consists of an A (anisotropic) band and an I (isotropic) band (Fig. 2, 3). The A band in a relaxed vertebrate muscle is approximately 1.5 microns in length; that of the I band is approximately 0.8 micron.[15] The middle of the A band often has a less dense area called the H zone. The H zone has through its center a faint stripe (the M line). On either side of the M line are two lighter areas (the L zone). The dense area of the A band on either side of the L zone is sometimes called the S zone.[19] The I band has a double refractive line (the Z line). A faint line can sometimes be seen on either side of the Z line; this is called the N line. From one Z line to the next constitutes a sarcomere—the structural and functional muscular unit.

Around the myofibril is a tri-dimensional lattice which Gelfan[20] describes as forming a lace-like sleeve (Fig. 2). It was first noted by Porter, Claude, and Fullam in 1945[21] in a study of tissue culture cells. It is peppered on the outside with particles of Palade which are thought to be ribonucleic acid (RNA) granules. These particles are 80–300 Å. in diameter and often lie very close to the mitochondria.[22] This tri-dimensional lattice consists of membranes that form tubules with cisterna-like dilations in a pattern which repeats itself with each sarcomere.[23] It is called the sarcoplasmic or endoplasmic reticulum. It connects with the Z lines in the I band of the myofibril and sometimes with the N and Z lines.[22] The impulse traveling along the sarcolemma is thought to penetrate the muscle fiber via a component of the sarcolemma.[23, 24, 25]

Around and between the lattice of endoplasmic reticulum is the soluble part of the cytoplasm (the sarcoplasm). This is about 40 per cent of the volume of the muscle cell. It surrounds all the formed elements and fills up the remaining spaces in the cell. The sarcoplasm between the myofibrils is called the interfibrillar sarcoplasm. This is continuous at the cell margin with the subsarcolemmic or peripheral sarcoplasm and with the perinuclear sarcoplasm. The sarcoplasm contains the lipid inclusion, dense particles, myogen, the sarcoplasmic reticulum, and the mitochondria.[23]

6. The Mitochondria and Sarcosomes

Kitiyakara and Harman,[26] using phase microscopy, noted in the breast muscle of the pigeon at least two granules, one of which is a mitochondrion, similar to those of other tissues, and

* The Ångstrom unit, abbreviated Å, is a convenient unit for indicating dimensions of objects of molecular or macromolecular size. It is equal to 0.1 of a mμ (millimicron) or 0.0001 of a μ (micron), or to 10^{-8} cm.

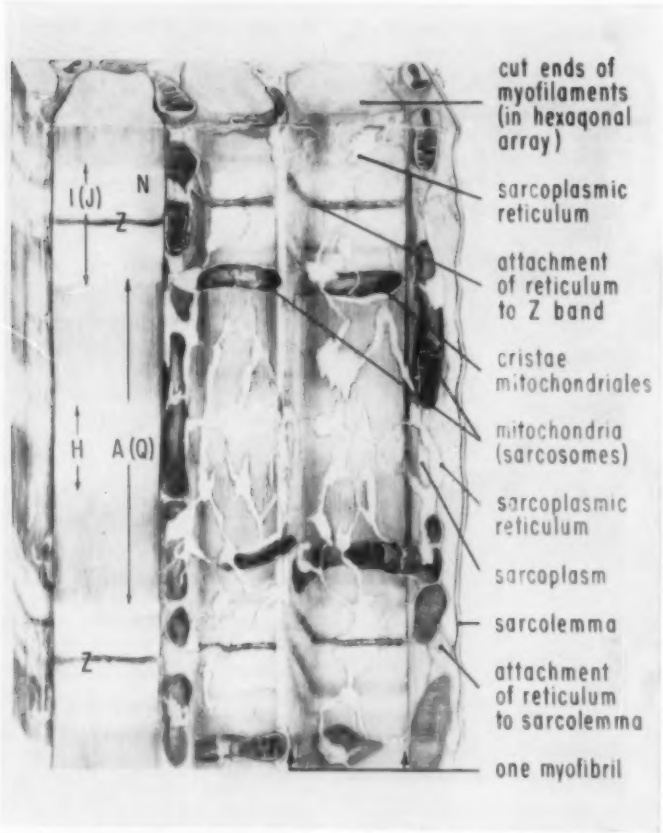

FIG. 2. Three-dimensional drawing of a block of muscle about 1x3x5 microns, showing detail revealed by the electron microscope (Bennett, H. S., Szent-Gyorgyi, A., Denny-Brown, D., and Adams, R. D. What We Need to Know About Muscle. *Neurology*, 8:65-79, 1958).

a second granule peculiar to muscle, which they called a sarcosome. Other investigators use the term sarcosomes interchangeably with mitochondria. The sarcosomes and mitochondria have a close chemical similarity and are closely bound together by the connecting bridges observed by electron microscopy. In breast muscle of the pigeon the mitochondria are 2–10 microns in length, and the sarcosomes 0.1–0.3 microns. The mitochondria are irregularly rod-shaped (Fig. 2).[27, 28] The sarcosomes are round or elliptical. The mitochondria have a coiled gel structure and possess a double membrane.[23] The coiled gel structure recognized as cristae is thought to be a folding of the inner membrane. Kitiyakara[29] states that the average diameter of the mitochondria in human muscle would be approximately the same as that of a myofibril (0.5–1.0 micron) and that the length of the mitochondria varies approximately between 1–2 microns. There is usually a direct relationship between density of mitochondrial content and the oxidative capacity of different muscles.[30] Harman[27] noted an exception to this relationship in the pectoralis major of the pigeon. Since the myofibrils lack oxidative enzymes it is proposed that the mitochondria furnish the adenosine triphosphate (ATP) required by the myofibrils for their contractility.[27]

7. The Myofilaments

A myofibril contains myofilaments. These filaments were first observed by Kölliker[31] (1888)

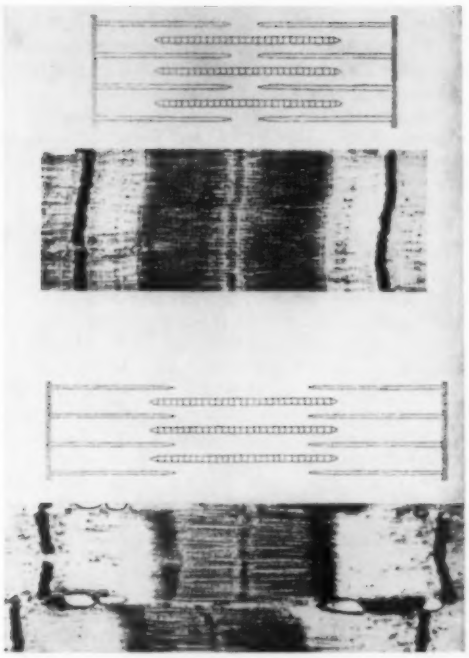

FIG. 3. Above is an electron micrograph showing two myofibrils in a stretched muscle and a drawing of the position of their filaments. The thick and thin filaments overlap only at their ends. Fig. 4 is a drawing showing the position of the filaments (Huxley, H. E. The Contraction of Muscle. *Scientific American*, 199:67-82, 1958).

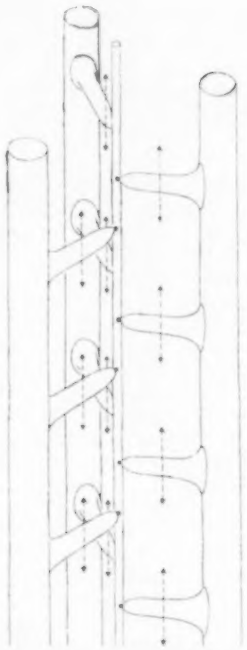

FIG. 4. Arrangement of cross bridges (Huxley, H. E. The Contraction of Muscle. *Scientific American*, 199:67-82, 1958).

and confirmed by Schmitt, Bear, Hall, and Jakus[32] (1947) who noted that these filaments did not bend or fold in contraction. They lie parallel to each other and have striations. Their diameter is 50–100 Å.[15] According to Sjostrand and Andersson-Cedergren,[19] the mean diameter varies with the degree of shortening. There are two kinds of filaments, one of which is twice as thick as the other. H. E. Huxley[15] reported the thicker filament to be approximtaely 100 Å. in diameter and 1.5 microns long; the thinner filaments are about 50 Å. in diameter and two microns long (rabbit). In cross-section, one thin filament is centered among three thick filaments in vertebrate muscle in hexagonal array.[33, 15] The thicker filament has a dense cylinder surrounding the core. The two kinds of filaments overlap for part of their length which produces the cross-bands of the myofibril (Fig. 3). The A band contains the overlapping thick and thin filaments; the H zone contains only the thick filaments, and the I band has only the thin filaments. In the middle of the I band the thin filaments pass though a narrow zone of dense material (Z line), the exact nature of which is unknown.[34]

The myofilaments are linked together at intervals of 60–70 Å. (Fig. 4). According to Bennett and Porter,[35] these were first seen by Retzius (1881) and later described by Heidenhain in 1911, but which seem to have been forgotten or ignored until 1953 when Bennett and Porter[35] noted them in an electron micrographic study. Each bridge is 60 degrees around the axis of the filament, with respect to the adjacent bridge, forming a helical pattern which repeats every six bridges or about every 400 Å. along the filament.[22, 15] This pattern joins the thick filament to each one of its six, adjacent, thin filaments once every 400 Å. According to Sjostrand and Andersson-Cedergren,[19] the L zone of the H band has no cross-bridges at resting length.

During contraction and stretching, the length of the dense area of the A bands remains constant (accuracy 5–10 per cent). The H zone of the A band, however, increases and decreases with the length of the I band.[36, 37] Hanson and

Huxley[38] have proposed that when the muscle changes length, the two sets of filaments (thick and thin) slide past each other. As the contraction continues, Hanson and Huxley suggest that the ends of the filaments crumple or overlap. Szent-Gyorgyi[39] suggests that, rather than folding or crumpling, the contraction is a rearrangement of protomyosin in the myosin molecule.

H. E. Huxley[15] postulates that the cross-bridges, by oscillating back and forth, cause contraction of the thick filaments, pulling the thin filament by a kind of ratchet action (Fig. 4). The cross-bridge is a part of the thick filament (myosin), and is able to hook onto a thin filament (actin), at an active site. A single bridge might thus hook onto an active site, pull the thin filament a short distance (approximately 100 Å.), and then return to its original configuration, ready for another pull. Thus, the molecular events responsible for the contraction can occur repeatedly at each active site in the muscle. If the process, by which cross-bridges attach to active sites on the actin filament, occurs at a definite rate, then there is only a certain period of time available for this to be accomplished. Since this time decreases as the speed of shortening increases, not all bridges are attached at a given moment. The number of ineffective bridges increases with increased speed of shortening, and the tension consequently decreases.

The Chemistry of Muscle Contraction

The main reservoir of the energy released by food stuffs is adenosine triphosphate (ATP). Although the metabolic process of fermentation takes place in the sarcoplasm, the ATP resynthesis is localized in the mitochondria. The energy-yielding processes, leading directly to muscular contraction, are localized exclusively in the myofibrils.

ATP function is twofold: it acts as a contraction substance if it is split, and as a relaxing and plasticizing substance if it is present without being split. However, it is not yet fully established that the presence of ATP is one of the immediate conditions of contraction.[40] It is conceivable that the energy stored in the energy-rich bond of ATP is at first transferred to other intermediary substances, and that it is from these unknown intermediary substances that the energy is transferred to the contractile proteins.

Before the sliding filament theory of contraction was as well accepted as it is today, Szent-Gyorgyi[39] explained contraction on the chemical findings that H meromyosin splits ATP, when activated under physiologic conditions, so that actomyosin was formed; and a reorganization of the protomyosin occurred so that the actomyosin contracted up to 80 per cent, which is the limit of contraction of normal living muscle.

The myofilaments contain actin, myosin, tropomyosin, ATP, magnesium, and ions. Myosin is made up of 6 sub-units: meromyosins. There are two kinds of meromyosins, the heavy (H) and the light (L). Meromyosins are made up of sub-units and protomyosins.[39] The H meromyosin interacts with actin, and the L seems to be involved in shortening. When L myosin and actin react with one another, actomyosin is formed.[40] The equilibrium between the actomyosin complex and its component is affected by ATP. The thick filament of the myofilament (AH) is L myosin; the thin filament (I) is actin. The energy necessary for contraction is transferred, in some as yet unknown manner, to the actin by a transphosphorylation of the terminal phosphate of ATP.

By x-ray diffraction during initial states of contraction, the muscle is seen to shorten, but its filaments do not. As a result of these findings and electron microscopic pictures, the sliding filament theory of contraction was proposed in 1955 by Hanson and Huxley;[38] i.e., during contraction the secondary (thin) filaments are pulled in between the primary (thick) ones. If the sliding is the only process in muscle contraction, the shortening should stop at 30–40 per cent, as soon as the Z membranes reach the A band. However, muscle can shorten up to 80 per cent, producing tension all the time. Szent-Gyorgyi[41] sums up the present concept of muscular contraction by saying "the sliding of filaments is linked to the specific steric arrangements in cross-striated muscle, where this sliding makes rapid shortening possible, being the secondary consequence of changes which we fail to understand."

The Efferent Innervation

The entry of the nerve into a muscle appears to be dependent upon the arrangement and length of fibers.[42, 43] Feindel, Hinshaw, and Weddell[44] observed that there was little indication that the intramuscular neural pattern can be determined from the size of the nerve, the number of nerves entering, or the site of the entry. According to Brash,[42] there are two chief forms of neurovascular hila. These correspond to the arrangements of the nerve to the muscle bundles. In long muscles, the nerves tend to be parallel to the muscle bundles, and in broad muscles, they tend to be at right angles to the muscle bundles.

Gurkow[43] found in her study of the hamster that regardless of the entrance of nerve branches, ultimately there are three main subdivisions in a

muscle. These subdivisions form an intramuscular neural plexus; and fibers arise from the plexus terminal. Some of the terminal fibers branch, but many do not. Some of these terminal fibers bundle together and then spray out and form motor end-plates. Because of branching, there may be more end-plates than fibers in a terminal branch. Except for the sartorius muscle, the direction of the terminal motor nerves is nearly at right angles to the muscle fibers.[1]

Bowden and Gutmann[45] state that in normal human muscle, axons rarely run for a long distance between the fibers before making contact with end-plates. The position of the end-plate appears in most cases to be in the central region of the muscle fiber.[46, 43, 1, 47] In the unipennate muscles, the end-plates form a transverse band through the middle of the muscle, except in the gracilis and sartorius muscles where two end-plate bands (gracilis) and a disseminated distribution of the end-plates (sartorius) can be seen. In the bipennate converging muscles, such as the tibialis anterior, an upwardly convex end-plate zone is seen. In the bipennate diverging muscles, an upwardly concave end-plate band exists. Since the terminal fibers travel a short distance, 0.5–2 mm., the end-plates of a bundle lie within a limited zone. As the branch of the axon approaches the striated muscle fiber, the myelin is lost. The endoneurium becomes continuous with a layer of reticular fibers over the sarcolemma. Coërs and Woolf[47] state that the nerve ending is separated from the sarcoplasm by the sarcolemma. The axon, consisting of neurofibrils, indents the sarcolemma, making a pocket on the surface of the muscle fiber. In man, the diameter of this pocket or sub-neural apparatus ranges from 10–80 microns, being larger in red muscle fibers than in white, and larger in muscle fibers of larger diameter.[47] Beneath the end-plate region in the muscle fiber there is an increase in the number of muscle nuclei. This is termed the sole of the motor end-plate.

Occasionally, (according to Jarcho, Eyzaguirre, Berman, and Lilienthal,[12] Hunt and Kuffler,[48] Christensen,[1] and Coërs and Woolf[47]), there are two end-plates on the same muscle fiber. Feindel, Hinshaw, and Weddell[44] occasionally found more than one end-plate on a muscle fiber, but the end-plates were always from the same axon. Gurkow and Bast[49] found in their study of the clavotrapezius and cleidomastoideus muscles of the hamster that there was one end-plate for every 3.7 muscle fibers. Buchthal[50] thinks that in normal healthy muscle of the human that there is at least one motor end-plate for each muscle fiber.

CONDUCTION IN NERVE AND MUSCLE

The activity of the neuromuscular mechanism involves three processes: excitation, conduction, and response. The phenomenon of excitation is the abrupt response of an excitable cell, which sometimes occurs as a result of a minimum change in its environment.

The cell membrane is primarily concerned with the active process of excitation. The sole function of nerve fibers is to transmit impulses from one part of the system to another. Conduction in nerve is effected by means of the nerve impulse. The conduction of the impulse is essentially the propagation of excitation along the nerve or muscle fiber. When one part of the fiber is stimulated to cause excitation, this segment is then able to stimulate adjoining segments of the fiber; and thus the impulse is propagated. It is generally assumed that ions are the carriers of electrical currents in living cells. Sodium ions are present at a much higher concentration on the outside of nerve and muscle fibers; the opposite is true for potassium ions. These concentration gradients are the source of the electromotive force of the action potentials which propagate the impulse.

The normal response of all irritable tissues involves a change in potential. The energy of the impulse is derived from the tissue itself. During propagation of an impulse there is an increase in the sodium ion permeability of the membrane which causes a change of polarity. The outside of the membrane becomes more negative. This change is recorded as action potential or action current. The influx of sodium ions is followed by an equivalent outflow of potassium ions. Acetylcholine is present, in resting conditions, in an inactive and bound form. During activity, acetylcholine is released from the bound form. The free acetylcholine acts upon a receptor; this action is responsible for the change of permeability and is thus responsible for the generation of the electric potential.[51]

Most of the heat produced during nerve activity is developed after the electrical changes, and is presumably associated with the restoration of the electrolyte distribution.

The contractile substance of the muscle does not function in an all-or-none manner, but functions in proportion to the stimulus.[52] The conduction of the impulse, however, does function in an all-or-none manner. This conduction travels along the sarcolemma and into the muscle fiber, probably via the sarcoplasmic reticulum.[23, 24, 25]

The propagation velocity of action potentials in human muscle from voluntarily activated

muscle fibers is higher, 4.72 meters per second (m./sec.), than that following an electrical stimulus, 4.02 m./sec.[53] Denslow and Hassett[54] found that the velocity after voluntary activation varies from 1.3–12.5 m./sec.

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A Review of Sensory Receptors in Skeletal Muscles With Special Emphasis on the Muscle Spindle

Virginia F. Harrison, Ph.D.*

TYPES OF RECEPTORS IN SKELETAL MUSCLE

In skeletal muscle, sensory nerves terminate in end-bulbs, in spiral endings, Golgi tendon organs, and in complicated end-organs termed muscle spindles or neuromuscular bundles. The end-bulbs or Golgi Mazzoni bulbs are oval in shape and are located in the perimysium.[1] The bare axons terminate in the bulb of lamellated connective tissue in a number of branches which twist and interlace to form a glomerulus. They are considered to mediate sensation of compression.

The spiral endings[2] are simple endings curled around several fibers three to eight times. They are found around the larger muscle fibers in the extrinsic muscles of the eyes, near the center of the belly, just distal to the band of motor fibers. Zwirner[3] also noted them in his study of the muscles of the larynx.

The Golgi tendon organ is a specialized encapsulated structure surrounding a bundle of tendinous fibrils which receives the attachment of 15–30 muscle fibers. Golgi tendon organs are situated at the musculotendinous junction and not actually in the tendon.[4] Each organ has a single large-caliber nerve fiber. The Golgi tendon organs are considered to be responsive to high-threshold tension stimuli.[5]

THE MUSCLE SPINDLE

1. Historical Review

According to Batten,[6] Miescher in 1848 was the first to see the spindle. Weismann[7] described the spindle accurately, but he thought the spindles were embryonic muscle. It was Kühne[8] (1863) who named the neuromuscular organ the "muscle spindle." In 1888, Kerschner[9] surmised that the muscle spindle was sensory. It remained indeterminate until Sherrington[10] proved by a degeneration experiment that the muscle spindle was sensory. Ruffini[11] provided the first complete histologic description of the innervation of the spindle. In 1928, Fulton and Pi-Suner[12] proposed the concept of "in parallel" for muscle spindles and "in series" for the Golgi tendon organs. In 1933, Matthews[5] performed the classic experiment on the cat, demonstrating that spindle discharge was induced by stretch and/or contraction of muscle. In 1945, Leksell[13] discovered that the small-diameter motor fibers going to a muscle serve as regulators of sensory activity which originates in the muscle and activates the small intrafusal spindle fibers. In 1948, Barker[14] wrote a thorough description of the muscle spindle in the rabbit. In 1951, Hunt and Kuffler[15] demonstrated that spindle discharge was induced by electrical stimulation of the small (gamma) nerve fibers. Coërs and Durand[16] (1956) found that the flower-spray endings of muscle spindles in humans were motor endings. Voss[17] and Cooper and Daniels[18, 19, 20] have demonstrated muscle spindles in all muscles examined, except the posterior belly of digastric and stapedius muscle. Therefore, muscle spindles are not limited to antigravity muscles in man. Studies of the muscle spindle have been made in the cat, dog, guinea pig, mouse, man, rat, rabbit, goat, hedgehog, lizard, pig, giraffe, sheep, tortoise, dove, and monkey.

2. Structure of the Muscle Spindle

Muscle spindles are fusiform-shaped receptors composed of a laminated connective-tissue capsule, blood vessels, nerves, lymph vessels, and

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This study was supported by a grant from the Wisconsin Alumni Research Foundation.

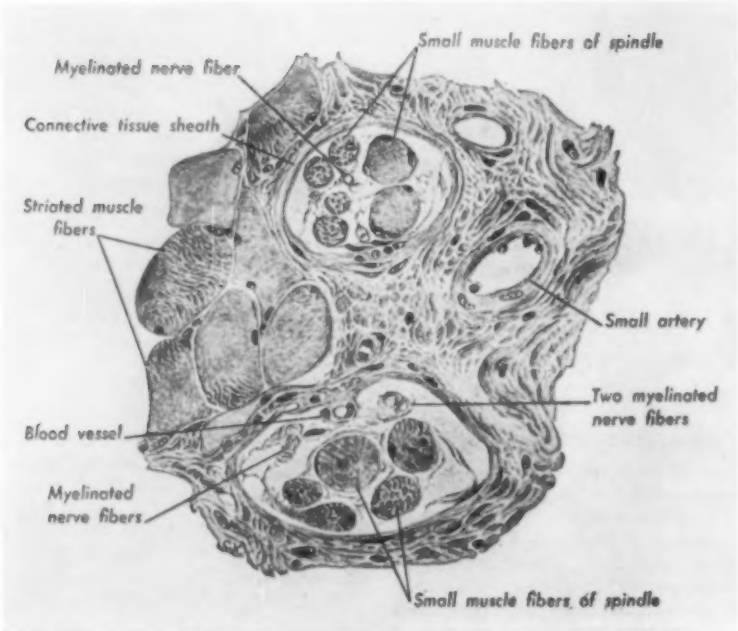

FIG. 1. Cross section of two muscle spindles in skeletal muscle of monkey (Copenhaver, W. M., and Johnson, D. D., eds. *Bailey's Textbook of Histology*, 14th ed. Baltimore, Williams and Wilkins, 1958).

intrafusal muscle fibers (Fig. 1). The muscle spindle is divided into a central region called the equatorial region and two extremities (the poles). Muscle spindles may be simple, compound, triple or quadruple, lying side by side or in tandem, their ends sometimes overlapping.[21, 22] The muscle spindle may be attached to the extrafusal endomysium, tendon, perimysium, or tendon organ.[14, 23]

The typical spindle in the adult human[1] has a length of 2–20 millimeters (mm.) and a diameter of .15–.4 mm.[6] The size of the spindle varies with age and length of the muscle, being longer in the adult than in the child, and longer in the longer muscles. The muscle spindles are located in the areas of the muscles that are subject to the greatest stretch.[17] In muscles with a *greater* density of spindles, the spindles are concentrated around the area of the nerve entry. In muscles with a *lesser* density of spindles, the spindles are spread out more evenly. The synergists and the antagonists have an almost equal number of spindles. However, there are proportionally more gamma fibers to the flexor muscles than to the extensor muscles of the leg (cat).[24, 25]

The capsule of the muscle spindle has 6–8 lamellae. In the rat, these consist of very thin sheets of fibroblast cytoplasm separated by narrow clefts containing collagen fibrils. The sheets form a number of concentric tubes whose walls are thinner than capillary endothelium. The capsule is continuous with the neurilemma of the associated nerves.[26] On its inner side, it is delimited by the periaxial space. On the outer side, it is separated from the perimysium, except at the poles and at individual points around the periphery. Toward the poles of the spindle, the capsule sends in many stout bands which invest the individual intrafusal fibers. The capsule invests fibers at the poles so closely that no periaxial space is seen.[18] The proximal and distal poles of the spindle are indistinguishable.

The axial sheath surrounds the bundle of intrafusal fibers in the region of the equator. It is united to the inner wall of the capsule by delicate septa which bridge across the periaxial space.[14] Batten[6] describes the periaxial space as a lymph space. Lymphatic vessels were seen by Batten which ran parallel to the course of the intrafusal fibers, and connected with "extrafusal" lymphatic

vessels. The intrafusal bundle is not fusiform in shape; it hardly alters in diameter (about 32 microns) throughout its extent.[10] The intrafusal fibers extend from pole to pole or insert into the side walls of the capsule.[21, 27] The shape of the intrafusal fiber in cross-section is circular with a usual diameter of 7–20 microns, whereas the extrafusal fiber is polygonal with a usual diameter of 20–40 microns.[10] Robertson[28] found that the intrafusal fiber surface in a frog is thrown into a number of folds. These folds sometime extend as finger-like processes in the middle portion of the muscle fiber. Each intrafusal fiber (frog) contains a centrally placed nucleus surrounded by a thin layer of sarcoplasm containing a few myofibrils.[28] The striations of the intrafusal fibers are generally coarser than the extrafusal fibers. Batten[6] found a ratio of 10:13.

3. Types of Intrafusal Fibers

There are two types of intrafusal fibers: large and small. The larger fibers extend from one end of the spindle to the other. In the middle of a large fiber, the equatorial region, there is a nuclear bag. On either side of the nuclear bag is the constricted myotube region. Batten[6] and Cooper and Daniel[19] found that the large nuclear bags in human spindles are covered by a thin layer of striated fibrils with a shell of filaments. These fibrils are continuous throughout the length of the intrafusal fibers. The nuclear bag has an aggregation of 40–50 spherical nuclei, each measuring about 6 microns.[10] The nuclear bag is about 100–150 microns long.[14]

The small intrafusal fiber is smaller in diameter, as well as shorter in length. It extends about half the total length of the spindle. It has no nuclear bag but does have a row of concentrated nuclei in the equatorial region.

4. Innervation of the Muscle Spindle

Sherrington[10] noted that the nerve fibers enter the spindle from the side, usually near the junction of the equatorial to the proximal region. Large and small myelinated nerves wind through the capsule, lose their myelin sheath, and terminate on the intrafusal fiber.[26] There are two types of sensory endings: primary, 8–12 microns in diameter, and secondary, 6–9 microns in diameter. Primary endings are always present. They end on the nuclear bag and small portions of the myotube region of the *large* intrafusal fibers. They end on the central equatorial region of the *small* intrafusal fibers. They deeply indent the sarcolemma and the underlying thin layer of poorly striated myofilaments. The secondary sensory endings may or may not be present.[14, 27, 18]

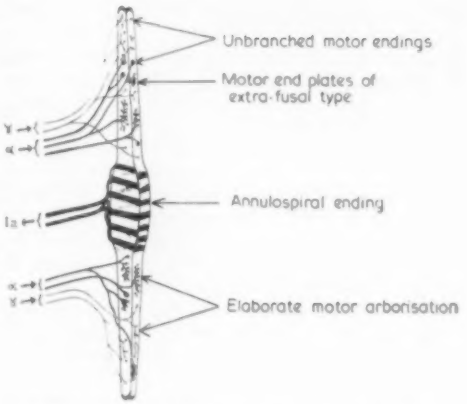

FIG. 2. Diagram showing nerve fibers and their endings on a muscle spindle as seen in preparations stained vitally with methylene blue (Coërs, C. and Woolf, A. L. *The Innervation of Muscle* Springfield, Ill., Charles C Thomas, 1959).

They are found only on the small intrafusal fibers and are confined to the distal equatorial portion of the fiber. Coërs and Woolf[1] question whether these so-called secondary sensory endings are sensory. These authors have concluded from their histologic study that if two sensory endings exist they must both be of the annulospiral type. The primary and/or the secondary endings in the human terminate by winding spirally about the intrafusal fibers.[1]

Each intrafusal muscle fiber is innervated at its poles with small myelinated motor fibers (4–7 microns). Additional motor nerve fibers are located between the polar motor fibers and the sensory fibers[21, 1] (Fig. 2). This finding somewhat fits the observations of Pascoe[29] who noted two physiological types of gamma fibers. One type of gamma fiber is inhibited by slight stretch of the muscle. The second type is unaffected by such passive tension changes in the muscle, but maintains a regular discharge frequency which is influenced only by stimuli that cause strong reflex movements.

The motor fibers lose their myelin sheath just before contact with a muscle fiber, thus presenting a marked constriction, the preterminal node. Shortly beyond the node the fibers flatten, and hence increase greatly in diameter as they approach their end-plates.[30, 14] A nerve fiber, possessing an average axon diameter of approximately 1 micron, as it approaches the muscle fiber may thus increase in diameter to 3–4 microns shortly before terminating. The termination of the end-

plates are fine neurofibrillar brushes (or pointed tapers) 50–70 microns in length. The motor end-plates on the intrafusal fibers are generally similar to those on the extrafusal fibers and probably have the same relative position on the muscle fiber, i.e., epilemmal.[23]

In contrast to the localization of the motor end-plates at the middle of extrafusal fibers, the end-plates in the intrafusal fibers are scattered along the whole length of the muscle except for the equatorial region.[16, 1] The concentration of the intrafusal motor end-plates is usually greatest in the juxta-equatorial region.

Morphologically, there are three main types of motor end-plates on the intrafusal muscle fiber. One type resembles the extrafusal motor end-plates, except that it may be more elaborate and extended. These end-plates originate from middle-sized alpha axons and are distributed throughout the length of the muscle fiber.[1] The second type of motor end-plate on the intrafusal fiber is a club-like expansion and originates from unbranched, middle-sized, alpha nerve fibers and small (gamma) nerve fibers. The third type of motor end-plate is a verrucose dilation. This type originates from the small gamma axons that produce elaborate arborizations. In the cat, these endings resemble the flower-spray endings[16] described by Ruffini.[31] Coërs and Woolf[1] think that this third type of motor ending in the human does not resemble the flower-spray endings, as seen in the cat, because the human spindle is usually longer and, hence, has a greater dispersion of various motor endings.

Boyd[32] found that the large intrafusal muscle fibers always have discrete motor end-plates well toward the poles. The small intrafusal muscle fibers have very small end-plates near the equator and sometimes a diffuse network covering the muscle fibers almost from end to end. Sometimes the ultra-terminal twig from a large end-plate forms a smaller end-plate on the same muscle fiber or on a neighboring fiber. It has also been observed that single, small nerve fibers can supply more than one spindle.

There are small nerve fibers within the spindles less than 0.5 micron in size which do not increase in diameter before branching. These are sympathetic fibers.[33, 34, 14]

5. *Variations in the Structure of the Muscle Spindle*

Variations occur in the structure of the spindle. The spindles in the extrinsic muscles of the eye are smaller (0.05–1.64 mm. in length and 0.02–.1 mm. in diameter) than spindles in the other somatic muscles of humans (2 mm.–2 cm. in length[1] and .15–.4 mm. in diameter).[18, 35, 19, 36] The capsule of the muscle spindles in the extrinsic eye muscles is 2–3 lamellae thick in contrast to that of the spindle in other human somatic muscles which is 6–8 lamellae thick.

In the extrinsic muscle of the eye, some of the intrafusal fibers are the same size as the extrafusal fibers.[35]

The number of intrafusal fibers in muscle spindles of the adult is less than in the fetus.[37]

The muscle spindles may lie partly in muscular tissue and partly in connective tissue, or they may lie wholly in connective tissue.[6, 18]

6. *Evolutionary Specialization of Muscle Receptors*

Histologic examination of muscles in different vertebrates indicates an evolutionary specialization of muscle receptors. Spindles are unknown in fishes although *terminaisons en panier* which clasp the ends of the muscle fibers, and which are presumably stretch receptors, have been described.[38] In urodeles, in addition to *terminaisons en panier*, there are rudimentary unencapsulated spindles. These take the form of one or a small group of ordinary muscle fibers about which a sensory fiber is entwined. Spindles of more than one fiber are said to have a motor innervation. In the frog, in addition to *terminaisons en panier*, there are true encapsulated multifiber spindles with enveloping afferent endings. The reptilian spindles seem to be similar to the frog except that the intrafusal fiber is single. In mammals, specialization has progressed to the extent that two sensory endings are often encountered on the same fiber, and the motor innervation is separated from the innervation of extrafusal fibers.

7. *Function of the Muscle Spindle*

Generally, the muscle spindles are arranged parallel to the extrafusal fibers. The spindle afferents have a repetitive discharge which increases with muscle stretch and decreases during sustained contraction. The fusimotor (gamma) nerve fibers, which usually have a low repetitive discharge of 0.5–1 sec. (20 degrees Centigrade)[39] may increase in rate and thereby increase the activity of the spindle.[40] A current concept of the function of the muscle spindles is that they ensure tension, being proportional to stretch,[41] and ensure feedback action so that the contraction is accurately related to the effort made.[42] In other words, they detect the difference between the length of the main muscle and the muscular poles of the spindle. The stretch reflex, excited by impulses from the spindle, tends to keep the main muscle at the same relative length as the spindle

(servo action). In a steady, voluntary or postural effort, the length of the muscle is determined by the rate of the tonic innervation of the intrafusal fibers[43] which sets their length. Shortening involves an increased excitation of the intrafusal fibers: as they shorten, the main muscle follows by servo action. Descending pathways, mediating voluntary movement have a direct regulatory influence on the small motoneurones innervating the spindles. Sudden effort excites the motoneurones to extrafusal muscle directly, which avoids delay due to conduction time to and from the spindle.[42, 44] However, Pascoe[29] observed that a second type of gamma fiber was influenced only by stimuli that caused strong reflex movements.

The function of the middle-sixed axons of the alpha group supplying the intrafusal fiber has not been determined.

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A Review of the Motor Unit

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HISTORICAL REVIEW

Luigi Galvani, in reporting his experiments with neuromuscular preparations of frog legs in 1791, demonstrated the two fundamental electrical properties of muscle: (1) that muscle contracts when electrically stimulated, and (2) that an electrical current is produced in the process of muscular contraction.

Piper[1] (1907) was the first to obtain an electromyogram during voluntary contraction in the human by employing a string galvanometer. He tested the flexors of the forearm by placing string electrodes soaked in zinc sulfate around the wrist and above the middle of the forearm. As the forearm lifted progressively heavier loads, there was an increase in amplitude of the potentials, but no change in frequency. The frequency in voluntary tetanus was 47–50/sec. (per second), and this unchanging frequency was later called "Piper rhythm." The term "motor unit" was not defined in Piper's time.

It was not until Liddell and Sherrington's experiments in 1925[2] that the term "motor unit" was used. They defined it as a "motoneuronaxon and its adjunct muscle fibers." They observed the vastocrureus muscle of a decerebrate cat and postulated that, with stimulation of the nerve, the motor unit reacted in an all-or-none fashion.

Adrian and Bronk[3] (1928) succeeded in obtaining action potentials from a single motor fiber. By dissection methods, action potentials from single motor fibers of the phrenic nerve of the rabbit were obtained during the normal respiratory discharge. During normal breathing, the action potential in each nerve fiber had a frequency of 20–30/sec. throughout the period of inspiration. The amplitude of the action currents remained unaltered during changes in the inspiratory effort. The only change was the frequency of discharge in the nerve. Adrian and Bronk did not demonstrate that additional neurons are recruited when the strength of inspiration increases, but this was subsequently shown by Bronk and Ferguson[4] (1935).

Denny-Brown[5] (1929) studied the stretch reflex, using silver-chloride pin electrodes in the soleus muscle of the cat. He observed that the rate of discharge was considerably lower than 50/sec. and that the frequency did not change. He was the first to explain the slow rhythm of the potentials as being due to the responses of a single motor unit. He believed that the gradation of contraction was brought about by increasing the number of active motor units.

In 1929, Adrian and Bronk[6] designed the coaxial needle. This consisted of a small hypodermic steel needle into which an enameled-covered copper wire, bared at the tip, was inserted. Records were made from the muscles in the hind limb of the cat. Flexion and crossed extension reflexes were produced by pinching the foot, and the discharges in the nerve fibers supplying the peroneus longus, tibialis anterior, vastus medialis, and vastus lateralis muscles were recorded. When a coaxial needle was inserted into the muscles, the action potentials (recorded from the muscle) mirrored the discharges recorded from the single nerve fibers; therefore the laborious technic of dissecting single motor fibers could be circumvented. The coaxial needle was then used in the study of the human triceps. Slow voluntary contraction produced action potentials at a rate of 5–6/sec. As the voluntary contraction increased, the rate increased to approximately 50/sec., and additional motor units were recruited. They also noted that when the muscle was relaxed it was electrically silent.

Kugelberg and Skoglund[7] (1946) demonstrated that the frequency of contraction of motor units varied with the strength of stimulus. They recorded the motor-unit action potentials from the first dorsal interosseus muscle in the foot by

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This study was supported by a grant from the Wisconsin Alumni Research Foundation.

stimulating the peroneal nerve at the level of the knee. They also noted that when the muscle was relaxed there was no activity in the motor units.

Other types of needle electrodes have been used in the human. Hoefer and Putnam[8] used bipolar electrodes. Jasper and Ballem[9] used a monopolar needle electrode. Norris and Gasteiger[10] (1955) used a microneedle electrode to record discrete motor-unit potentials during maximum contraction.

In 1955, Feinstein, Lindegård, Nyman, and Wohlfart[11] did the first morphologic study of motor units in normal human muscle. This has been followed by electromyographic studies of the topography of the motor unit by Denslow, Gutensohn, Chace, and Kumm,[12] using multiple electrode placement, and by Buchthal *et al.*[13, 14] using two needles each of which contained 12 electrodes (multi-electrode).

THE ANATOMY OF THE MOTOR UNIT

The available knowledge of the anatomy of the motor unit is limited. Until the study by Feinstein, Lindegård, Nyman and Wohlfart's[11] was reported little was known of the arrangement of the muscle fibers of the motor unit in human muscle from direct histological observation.

1. Topography of the Motor Unit

Some electrophysiologic studies have shed light on the anatomy of the motor unit. Cooper,[15] in her study of the tenuissimus muscle of the cat (1929), noted that when she stimulated the nerve the muscle fibers contracted along the length of the muscle. She interpreted this as evidence that the muscle fibers of a motor unit were located in a chain-like linkage. Lindsley's[16] evidence from an electromyographic study in 1935 on the human agreed with Cooper's interpretation. In 1949, Denny-Brown[17] observed motor units electromyographically from 5–10 centimeters (cm.) in length. Denslow, Gutensohn, Chace, and Kumm[12] (1957), in their multiple electrode placement study of the motor unit, also observed that action potentials of single motor units in the human tibialis anterior and biceps brachii were arranged in a strip-like pattern which was roughly parallel to the long axis of the muscle. Two active areas separated by an inactive area were never seen. Although the active areas were contiguous, they did not necessarily occupy the same plane in the muscle.

Using multi-electrode leads, Buchthal, Erminio, and Rosenfalck[14] (1959), also studied the motor-unit topography in some of the muscles of the upper and lower extremities (Fig. 7). They used two multi-electrode needles inserted at right angles to each other. The fibers of a motor unit were found to be confined to a circular area of 5–7 millimeters (mm.) diameter in the muscles of the upper extremities and of 7–10 mm. diameter in the lower extremities. Such areas allow space for the interdigitation of approximately 25 motor units, each comprising 500–2000 fibers. Within the same muscle, the localized area (from which the action potential of a particular motor unit could be recorded) varied by a factor of four because of the size of the unit.

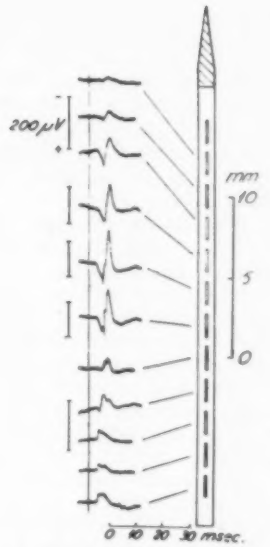

FIG. 1. A multi-electrode and action potentials from a motor unit in the human biceps brachii recorded by eleven leads. The lead nearest the tip is the indifferent electrode (Buchthal, F., Guld, C., and Rosenfalck, P. Multi-electrode Study of the Territory of a Motor Unit. *Acta Physiologica Scandinavica*, 39:83-104, 1957).

Feinstein *et al.*[11] found that the cross-sectional area of motor units varied in different muscles. In the medial head of the gastrocnemius the cross-sectional area was 3.4 mm.;^{2} in the tibialis anterior it was 1.7 mm.;^{2} in the first lumbrical of the hand it was 0.032 mm.;^{2} and in the platysma it was 0.0008 mm.^{2} (Table 1).

2. The Innervation Ratio

The earliest study of the relative number of muscle fibers per nerve fiber was done in 1851 by Reichert[18] who found a ratio of 1:22 in the sternocutaneous muscle of the frog. Tergast[19]

(1873) found a ratio of 1:3 in the eye muscles of the sheep, and 1:80 to 1:125 in the limb muscles of the dog. Clark[20] (1931) defined the innervation ratio as the ratio of *motor* nerve fibers supplying a muscle to the number of muscle fibers and found ratios of 1:120 in the soleus muscle, and 1:165 for the extensor longus digitorum muscle in the cat. However, he was not fully aware of the differentiation of motor and sensory fibers in nerves supplying muscles.

Feinstein *et al.*[11] (1955), in their morphologic study of the motor unit in the human, considered Leksell's[21] conclusion (1945) that small, group A motor fibers (gamma fibers) innervated intrafusal fibers of muscle spindles. These fusimotor fibers account for over 30 per cent of the efferent fibers to the striated leg muscles in the cat. They also appreciated that approximately 40 per cent of the large fibers supplying striated muscle are afferent.[22, 23] They found mean innervation ratios of 1:1634 in the gastrocnemius; 1:637 in the tibialis anterior; 1:108 in the first lumbricalis; 1:410 in the brachioradialis; and 1:25 in the platysma muscles (Table 1).

In the human extrinsic eye muscles and the tensor tympani, Torre[24] (1953) gave ratios of 1:7. This figure was not corrected for small and large afferent nerve fibers.

In the future, perhaps, other factors will have to be considered in determining the innervation ratio of the extrafusal fibers; for example, (1) the presence of multiple end-plates which were demonstrated in rabbits and macaque monkeys by Feindel, Hinshaw, and Weddell.[25] However, no anatomic evidence was obtained in support of innervation of single mammalian muscle fibers by more than one axon. Some physiologic studies, however, seem to indicate that a large number of muscle fibers are multiply innervated.[26] (2) If some muscle fibers in humans do not receive motor end-plates, as Gurkow and Bast[27] found in the hamster, the innervation ratio would be affected. (3) If peripheral sprouting of nerve fibers occurs during normal growth of muscle, the innervation ratio would be different at different ages.

3. Number of Motor Units in a Primary Bundle

Wohlfart[28] observed that the fibers of human striated muscle are organized in small (primary) bundles containing 10–300 fibers. In atrophies of neurogenic origin in which the muscle was but slightly affected, Wohlfart[29] found that 10–50 fibers in the primary bundles were atrophied; the other fibers in the bundle were healthy. Buchthal, Guld, and Rosenfalck[30] found in a similar study that 3–17 fibers in the primary bundles had atrophied, but the others were healthy. From these studies it was concluded that primary bundles contain fibers of two or more motor

TABLE 1. (Feinstein, B., Lindegard, B., Nyman, E., and Wohlfart, G. Morphologic Studies of Motor Units in Normal Human Muscles. *Acta Anatomica*, 23:127-142, 1955).

1. Material	2. Muscle	3. No. of large Nerve Fibers	4. No. of Muscle Fibers	5. Calculated No. of Motor Units	6. Mean No. of Fibers per Motor Unit	7. Mean diam. of Muscle Fibers in microns	8. Cross sectional area of Motor Units mm²
♂22	Platysma	1,826	27,100	1,096	25	20	0.008
♂40	Brachio-	right 525	> 129,200	315	> 410	34	
	radialis	left 584		350			
♂22	First dorsal	199	40,500	119	340	26	0.18
	interosseus						
♂54	First	155	10,038	93	108	19	0.031
♀29	lumbrical	164	10,500	98	107	21	0.037
♂40	Anterior	742	250,200	445	562		
♂22	tibial		292,500		657	57	1.7
♂28	Gastrocnemius	965	1,120,000	579	1,934		
♂22	medial head		946,000		1,634	54	3.4

units and that individual units have 3–50 fibers in the primary bundle.

4. Extent of the Motor Unit

The motor units with the largest number of fibers are those whose muscle fibers have the largest diameter.[11] However, the territory of any motor unit is only a minor fraction of the total cross-section of the muscle.[14]

5. Relation of Size of Motor Nerve to Size of Motor Unit

The diameter of the motor nerve fiber is believed by some to be related to the size of the motor unit it innervates. Eccles and Sherrington,[31] judging by the branching of the nerve fibers, found that large nerve fibers seemed to embrace more muscle fibers than the smaller nerve fibers. On the contrary, Kugelberg and Skoglund[32] found that electrical stimulation of large diameter nerve fibers evoked muscle action potentials of low amplitudes. They concluded that small motor units were innervated by nerve fibers of large diameter. A reinvestigation of this problem by Fernand and Young[33] found no correlation between nerve fiber size and size of the motor unit.

6. The Tension Value of a Motor Unit

The average tension which can be developed by a single motor unit was determined by Eccles and Sherrington.[31] They divided the total number of motor units in a muscle (arrived at by actual count of the fibers before branching in a motor nerve) into the amount of tension developed when the motor nerve was maximally stimulated. The semitendinosus muscle of the cat has some 630 motor units with an average tension value of 5.5 grams; the gastrocnemius medius has 430 motor units with a tension value of 30.1 grams; and the soleus has 250 motor units with a tension value of 919 grams. These values need to be increased about 30 per cent because the fusimotor nerve fibers were included in the nerve fiber count.

In the same paper, Eccles and Sherrington[31] describe an experiment in which they cut the ventral roots (cat) until just a few motor nerve fibers remained. By alteration of the strength of the tendon stimulus (tap), it was possible to obtain a graded response in normal tendon reflexes. When 2.5 grams of muscle tension resulted from a tendon tap, there was a single diphasic electrical response. When a 4-gram twitch was produced there was a double action current response. They concluded that 2.5-gram responses are twitches of single motor units, and the 4-gram responses are of two units.

7. The Effect of Afferent Stimulation on Motor Unit Activity

An afferent nerve activates only a fraction of the motoneurons supplying a given muscle. The size of the fraction of the motoneurons governed by the afferent nerve varies under different conditions; it is reduced by fatigue, oxygen lack, and anesthesia, and is increased by the administration of a small dose of strychnine. Even under the most favorable conditions, however, the number of motoneurons excited through a single afferent nerve fiber is not more than a fraction of those which can be excited by stimulating the motor nerve. Furthermore, the motor units excited through one afferent nerve do not lie in a single muscle, but are distributed throughout many different and often widely separated muscles.[34]

THE ACTION POTENTIAL OF THE MOTOR UNIT

Certain aspects of the anatomy of the motor unit may be elucidated by analyzing the action potentials of motor units.

1. Resting Muscle

There is a general agreement that the relaxed human limb muscles show no evidence of motor unit activity.[6, 10, 32, 35, 36]

The source of certain low amplitude potentials recorded over relaxed muscles in the lower limb, over the tibia and the patella (3 microvolts above a 2 microvolts noise level, frequency 40–50/sec.) is still obscure.[37]

The extrinsic muscles of the eye appear to have periodic minimal motor unit activity at rest. Breinin[38] inserted needle electrodes into the extrinsic eye muscles of a phlegmatic individual. When the individual seemed to be in a deep sleep, activity would cease for one to two minutes, then alternate with minimal motor unit activity. A cacophonous snore would result in a single burst of motor unit activity.

Smelser[39] found that the extraocular muscles in the guinea pig have a higher oxygen consumption rate than that of other muscles.

2. The Motor Unit Potential

According to Buchthal,[36] the term "motor unit potential" was introduced to differentiate it from fibrillation potentials of denervated muscle. As a result of the organization of the fibers of the motor unit in discrete groups of 3–50 fibers per primary bundle, spike potentials may

be led off from different points of a motor unit. The potential that is led off at one point represents only the activity of a fraction of the motor unit. Motor unit action potentials vary widely in duration, amplitude, and shape. To understand the summated potential, the origin of the motor unit potential must be considered.

The initial slow portion of the motor unit potential originates from the advance of depolarization towards the recording electrodes. When the impulse is propagated past the electrode, the potential from one or from a bundle of adjacent fibers, situated at a distance of less than one millimeter from the recording electrode, will appear as a spike discharge with a much higher amplitude than the component of the potential which arises from the other fibers of the unit. As the depolarization propagates away from the electrode, the return to the base line results from the summation of potentials from fibers of the unit more distant to the electrode.[40]

3. Some Factors Affecting the Motor Unit Potentials

The different propagation velocities of the action potentials in different fibers and differences in the site of innervation of the fibers of a motor unit affect the way in which the component potentials summate in the motor unit potential.

There is controversy as to variation in velocity between the different fibers of a muscle. Buchthal, Guld, and Rosenfalck[41,42] found little variation in velocity for the different fibers of a muscle, whereas Denslow and Hassett[43] found a definite variation. Denslow and Hassett found the rate of propagation to be 2.5–8.0 m./sec. (meters per second). According to Buchtal *et al.*,[42] during voluntary contraction the propagation is 4.7 m./sec. (36.5 degrees Centigrade) with a maximal variation of 30 per cent within the same muscle. The mutual interaction of the action potentials from adjacent fibers tends to equalize the propagation velocity of adjacent fibers with different diameters.[36] Such a mechanism has been demonstrated for frog's nerve.[44] The small variation in propagation velocity, according to Buchthal,[36] is of little importance in the explanation of action potential duration and variation in shape and duration.

The spread of the innervation sites is the other factor believed to account for differences in arrival time of the component parts of the action potential of the motor unit. Coërs[45] and Christensen[46] found (in human and other mammalian muscle) one narrow zone of motor end-plates localized in the middle portion of the muscle fibers. The sartorius and gracilis muscles were an exception with discrete transverse bands. This confirmed the findings of Kühne in 1864.[47] The purpose of an anatomic arrangement of multiple bands of innervation found in the sartorius and gracilis muscles might be to provide equally rapid excitation of long and short muscles. Buchthal, Guld, and Rosenfalck[42] state that in the innervation zone the action potentials have an abrupt onset within 0.5 milliseconds (msec.) between different points in the zone. Minute electrode displacement produces a steep negative deflection. Both the simultaneous onset and its abrupt negativity show that the recording takes place near the site of the initiation of the action potential. The average length of the innervation zone is about 25 mm. The end-plate scatter can account to a large extent for the excess in duration of the motor-unit action potential over the single fiber potential; and it determines the variation in the number of phases and the irregularities in shape of motor unit potentials.

4. Wave Form of the Motor Unit Action Potential

A single motor unit gives mono-, di-, tri-, and polyphasic action potentials.[43, 48, 49, 50] Di- and triphasic potentials comprise 80 per cent or more of all motor unit potentials;[10, 40] the diphasic potential is most characteristic of a single, motor-unit action potential when a needle electrode is used.[8, 10, 13, 48, 51] Polyphasic wave forms occurred in 3–5 per cent of all potentials in a study of the human biceps brachii muscle,[40] and in about 2 per cent in the gastrocnemius and rectus femoris muscles.[10] With moderate contraction, so many motor units fire that no discrete potentials can be seen. As a result of many units firing, an interference pattern is formed unless microelectrodes are used.

5. Duration of the Motor-Unit Action Potential

The duration of a single, motor unit potential is usually measured as total duration, i.e., as the time interval between the initial deflection from the base line and the point at which the terminal deflection again returns to the base line.

There are usually two phases to a motor-unit action potential. The first phase is a negative spike of a duration of 2–6 msec.[9, 52] The second phase is a positive spike which is slower than the first, having a duration of 5–8 msec.[52] The differences which have been found in the total duration are caused by (1) the type of electrodes used in recording the motor unit action potential; (2)

differences of duration of the motor-unit action potential in various muscles; (3) differences in age of the individuals tested and (4) other factors such as intramuscular temperature and successive recruitment.

Using unipolar micro-needle electrodes on limb muscles of normal humans, Jasper and Ballem[9] and Crue, Pudenz, and Shelden[51] found that the total complex duration of the motor unit varied from 2–10.2 msec. Weddell, Feinstein, and Pattle,[48] using concentric needle electrodes in human limb muscles, found that the duration of the motor unit varied from 5–10 msec. Norris and Gasteiger,[10] using bipolar micro-electrodes with an uninsulated area of an order of 100 microns,[2] noted that the duration of the motor-unit action potential varied from 3.80–5.1 msec.

The duration of motor unit potentials appears to vary in different muscles. Jasper and Ballem,[9] using monopolar electrodes with an exposed tip 25–50 microns in diameter, reported that facial muscles occasionally produce action potentials of 0.5 msec. duration. Faaborg-Andersen,[53] using concentric needle electrodes, with an outer diameter of 0.55 mm., noted durations of 3–6 msec. for the individual motor unit potentials recorded from the intrinsic muscles of the larynx. Feinstein, Lindegård, Nyman, and Wohlfart,[50] using concentric needle electrodes .6 mm. in outer diameter, noted motor unit potentials in the tibialis anterior of 10.6 milliseconds. Norris and Gasteiger,[10] using micro-bipolar electrodes with an uninsulated area of 100 microns,[2] recorded durations of 3.8–5.1 from the rectus femoris and 3.9–4.8 from the gastrocnemius. Buchthal[36] reported a mean duration of 12.8 msec. from the abductor digiti quinti, the longest duration of any human limb muscles that he tested (Table 2).

The differences in duration in different muscles might be partly explained on the predominance of red or white muscle fibers. The duration of potentials from white muscle is shorter than from red muscle. Adams, Denny-Brown, and Pearson[54] stated that the response of striated muscle in the cat to a single nerve impulse is a twitch lasting approximately 100 msec. in red muscle such as the soleus, and lasting but 23–40 msec. in white muscle such as the gastrocnemius and semitendinosus.

The total duration of motor unit action potentials increases with age.[55, 56] Using concentric needle electrodes, the mean action potential duration in infants in the tibialis anterior was 8.9 msec.; in 13-year-old children 10.00 msec.; in

TABLE 2. Mean action potential duration (msec.) in various muscles at different ages (concentric electrode). Deviations up to 20 per cent are considered within the normal range when comparing measurements in a given muscle with the values of the table (Buchthal, Fritz. *An Introduction to Electromyography*, Scandinavian University Books; Gyldendalske Boghandel, Nordisk Forlag, København)

Age in years	Arm muscles						Leg muscles					Facial mus.	Age in years
	Deltoideus	Biceps brachii	Triceps brachii	Extensor digitorum communis	Opponens pollicis; interosseus	Abductor digiti quinti	Biceps femoris; quadriceps	Gastrocnemius	Tibialis anterior	Peroneus longus	Extensor digitorum brevis	Orbicularis oris superior; frontalis	
0	8.8	7.1	8.1	6.6	7.9	9.2	8.0	7.1	8.9	6.5	7.0	4.2	0
3	9.0	7.3	8.3	6.8	8.1	9.5	8.2	7.3	9.2	6.7	7.2	4.3	3
5	9.2	7.5	8.5	6.9	8.3	9.7	8.4	7.5	9.4	6.8	7.4	4.4	5
8	9.4	7.7	8.6	7.1	8.5	9.9	8.6	7.7	9.6	6.9	7.6	4.5	8
10	9.6	7.8	8.7	7.2	8.6	10.0	8.7	7.8	9.7	7.0	7.7	4.6	10
13	9.9	8.0	9.0	7.4	8.9	10.3	9.0	8.0	10.0	7.2	7.9	4.7	13
15	10.1	8.2	9.2	7.5	9.1	10.5	9.2	8.2	10.2	7.4	8.1	4.8	15
18	10.4	8.5	9.6	7.8	9.4	10.9	9.5	8.5	10.5	7.6	8.4	5.0	18
20	10.7	8.7	9.9	8.1	9.7	11.2	9.8	8.7	10.8	7.8	8.6	5.1	20
25	11.4	9.2	10.4	8.5	10.2	11.9	10.3	9.2	11.5	8.3	9.1	5.4	25
30	12.2	9.9	11.2	9.2	11.0	12.8	11.1	9.9	12.3	8.9	9.8	5.8	30
35	13.0	10.6	12.0	9.8	11.7	13.6	11.8	10.6	13.2	9.5	10.5	6.2	35
40	13.4	10.9	12.4	10.1	12.1	14.1	12.2	10.9	13.6	9.8	10.8	6.4	40
45	13.8	11.2	12.7	10.3	12.5	14.5	12.5	11.2	13.9	10.1	11.1	6.6	45
50	14.3	11.6	13.2	10.7	12.9	15.0	13.0	11.6	14.4	10.5	11.5	6.8	50
55	14.8	12.0	13.6	11.1	13.3	15.5	13.4	12.0	14.9	10.8	11.9	7.0	55
60	15.1	12.3	13.9	11.3	13.6	15.8	13.7	12.3	15.2	11.0	12.2	7.1	60
65	15.3	12.5	14.1	11.5	13.9	16.1	14.0	12.5	15.5	11.2	12.4	7.3	65
70	15.5	12.6	14.3	11.6	14.0	16.3	14.1	12.6	15.7	11.4	12.5	7.4	70
75	15.7	12.8	14.4	11.8	14.2	16.5	14.3	12.8	15.9	11.5	12.7	7.5	75

20-year-old adults 10.8 msec.; in 30-year-old adults 12.3 msec.; in 40-year-old adults 13.6 msec.; in 50-year-old adults 14.4 msec.; in 60-year-old adults 15.2 msec.; and in 70-year-old adults 15.7 msec. (Table 2).

Several other factors have been shown to affect the duration of the motor unit potential. Decreasing the intramuscular temperature increases the mean duration 10–30 per cent per degree Centigrade. A regular diphasic potential which had a duration of 7 msec. at 37 degrees centigrade had a duration of 12.5 msec. at 0 degrees.[57] Mean values of duration are slightly higher in male subjects than in females; however, this variation is not significant statistically. There appears to be no significant statistical differences between the mean duration of motor unit action potentials in fatigued and non-fatigued muscle.[40] Action potentials that are successively recruited have the same duration.[58]

There is a difference in the duration of action potentials of motor units in relation to the strength of contraction. Using micro-bipolar electrodes with an uninsulated area of 100 microns,[2] Norris and Gasteiger[10] were able to record single action potentials in weak, moderate, strong, and maximal contractions. The lowest threshold motor units had the same mean duration as the highest threshold motor unit. The motor units that began firing during moderate contraction had the shortest duration; and the units that began firing during strong contraction had an intermediate duration.

6. *The Amplitude of the Motor-Unit Action Potential*

The voltage of muscle action potentials is the difference between the greatest positive and negative deflections. These action potentials may develop a voltage ranging from 100–10,000 microvolts. Many factors affect and/or are related to the voltage of the motor unit potential: (1) the size of the leading-off surface of the electrode; (2) the muscle tested; (3) the distance of the electrode from the spike source; (4) the depth of insertion of the electrode into the muscle; (5) the state of fatigue in the muscle; (6) the electrical impedance of the tissue surrounding the active fibers (the sub-unit) producing the spike of the action potential; (7) the fiber concentration; (8) the intramuscular temperature and oxygen supply; (9) the size of the territory of the motor unit; and (10) the numbers of phases in the motor unit potential.

The maximum amplitude which is recorded varies inversely with the diameter of the leading-off surface of the electrode until the diameter of the electrode is small in comparison to the diameter of the spike source.[59] For example, using concentric needle electrodes with a leading-off surface of 0.1 × 0.4 mm. (.04 mm.),[2] potentials were recorded as high as 4.2 millivolts; using electrodes .05 mm. in diameter (.002 mm.)[2], potentials were recorded with amplitudes as high as 10 millivolts.[30]

The mean voltage is different in different muscles. The mean amplitude in the rectus femoris is about one and one-half times as great as in the biceps brachii, whereas the mean amplitude of the opponens pollicis is almost three times as great as in the biceps brachii[14] (Table 3).

The distance of the electrode from the spike source accounts for some of the wide variation in voltage which results from random insertion of an electrode. Håkansson,[60] using an isolated frog muscle fiber, found that the logarithm of the amplitude of the action potentials decrease approximately linearly with the logarithm of the distance

TABLE 3. Mean values of motor unit territory and maximum voltage in normal muscles (Buchthal, F., Erminio, F., and Rosenfalck, P. Motor Unit Territory in Different Human Muscles. *Acta Physiologica Scandinavica*, 45:72-87, 1959).

Muscle	number of muscles	number of motor units	spike level (μV)	territory at spike level (mm)	standard deviation (mm)	maximum voltage (μV)	standard deviation (μV)
Biceps brachii	24	129	100	5.1 ± 0.2	2.4	370 ± 17	190
Deltoideus	7	52	100	6.7 ± 0.4	3.0	450 ± 27	190
Extensor digitorum communis	11	43	100	5.5 ± 0.3	2.1	800 ± 59	390
Opponens pollicis	10	34	150	7.4 ± 0.4	2.6	1,000 ± 83	500
Rectus femoris	9	65	100	(10.0 ± 0.6)	4.6	550 ± 38	300
Biceps femoris	5	35	150	8.8 ± 0.7	4.1	900 ± 67	400
Tibialis anterior	8	47	100	7.0 ± 0.4	3.0	620 ± 43	300
Extensor digitorum brevis	5	25	200	11.3 ± 0.8	4.1	3,000 ± 300	1,500

from the axis of the fiber, and that this was true of fibers of different diameters. Buchthal, Guld, and Rosenfalck[30] demonstrated the effect of distance of the spike source from the electrode in the human biceps brachii, using two multi-electrode needles, each containing 12 leads, 50–100 microns in diameter. Within a distance of 0.38 mm., the spike amplitude decreased to one-tenth of its maximum value.

The amplitude of the action potential is affected by the depth of insertion of the electrode. A deeply inserted electrode will record greater amplitudes than an electrode inserted near the surface of the muscle for the reason that the cannula will act more as a truly indifferent electrode the deeper it is inserted into the muscle, and potentials picked up by the cannula will interfere to a lesser degree with potentials picked up on the core of the electrode.[40]

Seyffarth[61] and Bigland and Lippold[62] noted that a diminution in amplitude of a single motor unit occurs during increasing fatigue.

The electrical impedance of the tissue surrounding the active fibers that produce the spike discharge (the sub-unit), affects the amplitude of the motor-unit action potential, since this tissue acts as an insulator. Bierman and Yamshon,[63] using surface electrodes, observed that the amplitude of the action potential appeared to depend to some degree on the thickness of the tissue interposed between the muscle under observation and the skin surface. As the thickness *increases* between the surface electrode and the active motor unit, a corresponding *decrease* is noted in the amplitude. Buchthal, Erminio, and Rosenfalck,[14] using multi-electrodes, noted that the higher the electrical impedance of the tissue surrounding the active sub-unit, the higher the voltage of the motor unit action potential.

A higher fiber concentration will cause a higher voltage. The higher fiber concentration may be caused by (1) fibers of smaller diameter, or (2) less connective tissue or less dense connective tissue, or (3) smaller primary bundles. Any of these factors would result in decreasing the distance between the recording electrode and active fibers and, hence, would result in a larger spike. The fiber concentration appears to be greatest in the intrinsic muscles of the hand and foot.[14]

Decreasing intramuscular temperature decreases the mean amplitude 2–5 per cent per degree Centigrade.[57] In anoxic muscle, kept at constant temperature, the voltage of the motor unit potentials is less than half that of a muscle with unimpaired oxygen supply.

Seyffarth,[61] and Buchthal, Erminio, and Rosenfalck,[14] believe that the amplitude of a motor-unit action potential is largely determined by the size of the unit and the distance from the electrode. Using multi-electrodes, Buchthal *et al.*[14] were able to compare the size of the motor unit to its maximum amplitude. They found there was a positive relationship between size of motor unit and the maximum amplitude recorded from the unit.

Usually, the amplitude of a motor unit potential is directly related to the number of phases in the potential. Polyphasic potentials are usually the largest in amplitude; monophasic are the smallest. Potentials of low amplitude (100 microvolts) tend to have short duration.[40] Also, the amplitude of the second recruited potential frequently exceeds that of the first.[35, 57] Buchthal *et al.*[57] found that in the abductor digiti quinti the mean amplitude of the second potential is 200 per cent higher than that of the first; in the biceps brachii the difference was 100 per cent. This increase in amplitude has been explained by these investigators as due chiefly to the decreasing distance of the electrode from the active fibers with increasing strength of contraction. Norris and Gasteiger[10] noted that during contraction the potentials of higher threshold units had higher amplitude. Potentials from the same motor unit began at a lower amplitude and increased until a maximum was reached. In a later study, however, Buchthal, Erminio, and Rosenfalck[14] found that neither the territory nor the maximum voltage of motor units varied systematically with low or high threshold motor units, nor did age or the degree of development affect the amplitude.

7. *The Frequency of the Motor Unit Action Potential*

As has been mentioned, there is a general agreement that in a normal relaxed human muscle there is no phasic motor unit activity. During the weakest possible willed contractions, the lowest regular frequency reported for a motor unit is 1/sec.[64] The highest frequency reported for individual motor unit activity is 150/sec.[10] The frequency discharge of the motor unit, which is most often reported in the literature, ranges from 5–7/sec. during weak effort and 50–60/sec. during maximal voluntary effort.[6, 36, 65] This frequency is lower than that of the whole muscle which can be as high as 450/sec.[8]

Frequency is affected or related to (1) the degree of tension in a muscle; (2) ischemia and nerve pressure; (3) fatigue; (4) recruitment of

motor-unit action potentials; and (5) red and white muscle fiber activity.

There is approximately a linear relationship between tension and frequency.[62, 66, 67] Norris and Gasteiger[10] found exception to this relationship during strong contractions when slowly discharging motor-unit action potentials appeared. The most sensitive motor units during strong contractions tended to become inactive for 1–2 msec., then burst into rapid frequency again. Except for strong contractions, the strength of contraction is brought about by recruitment of additional motor units and the increase of frequency in the active motor units.[6]

Ischemia will cause a decrease in frequency. Nerve pressure will also cause a decrease in frequency. Seyffarth[67] suggested that this may be due to an inhibiting effect of impulses from sensory nerve endings in the muscle. Norris and Gasteiger[10] believe the large, least excitable motor units supplied by high threshold neurones of the large axon diameter are selectively lost in pressure and ischemia.

There is a difference in findings of the effect of fatigue on frequency. Seyffarth[61] believes that when tension sinks in spite of the subject's effort to maintain it, inhibiting impulses in the muscle produce the decline in frequency. Lindsley[16] noted no variation in frequency with fatigue.

The recruitment of new motor units affects the frequency. As a rule, the frequency at the onset of each new unit is lower than the rate of those already present.[35] Also, at slight and constant effort the potentials from a single motor unit are discharged at a relatively constant rate, however, there appears to be a preference for intervals of 2.5–3 msec. between successive potentials.[68] These preferred intervals suggest to Rosenfalck and Madsen[68] the superposition of a periodic facilitation and inhibition not of peripheral origin.

8. The Coupling of Potentials of Motor Units

Double discharges, i.e., two potentials the second of which has the characteristics of the first, and firing within 20 msec. of the first, have been observed.[10, 69, 70] The double discharges are most apt to occur as the motor unit starts or stops firing. Buchthal[71] estimates that the maximum interval between the spike of a double potential is of the order of 10 msec.. The minimum is 2–3 msec. (absolute refractory period).

9. The Synchronous Activity of Motor Units

With weak effort and localized leads the occurrence of synchronized contraction of motor units in normal muscle has been described as present in exceptional cases.[8, 9, 10, 48, 52] Buchthal and Madson,[70] however, observed synchronicity of motor units 20 per cent of the time.

10. The Effect of Electrodes on Motor Unit Potentials

According to Floyd and Silver,[72] surface electrodes 1 cm. in diameter, placed several centimeters apart on the skin over a muscle, pick up the algebraic sum of the action potentials of all active units in the muscle. They[73] found with the inkwriter there is no loss of significant information, using either monopolar or surface electrode leads. Using an oscilloscope, Bigland and Lippold[74] noted that at low levels of activity in the extensor muscles of the fingers there was good correlation between needle and surface electrode during isometric contraction. Even better correlation was obtained when the needles were recording from a relatively large uninsulated area, than when only a minute area was denuded of insulation on the tip. During resistance, Hoefer and Putnam[8] noted on the oscilloscope that the action potentials were less frequent and less regularly recorded with a coaxial needle than with the surface electrode. This they attributed to the difference between motor unit potential to whole muscle potential.

Using an oscilloscope, Jasper and Ballem[9] advocated a monopolar electrode as it has no directional properties. Lundervold and Li[75] noted that a single fiber discharge is most accurately recorded by the monopolar needle, i.e., to avoid directional properties of a coaxial needle. However, Guld[76] compared several kinds of electrodes in human muscle and concluded that monopolar electrodes consisting of an insulated needle with a non-insulated tip area of 2500 square microns resulted in a longer duration and a greater amplitude than the concentric and bipolar electrodes. In other words, the monopolar electrodes provided worse recording conditions than concentric and bipolar electrodes. Landau[77] feels that the monopolar electrode has the advantage of recording locally the maximum voltage from the maximum volume of tissue. Lundervold and Li,[75] using a #20 venopuncture needle followed by insertion of monopolar, single-core concentric needle electrode and double-core concentric electrode, found the duration of fibrillation potentials in milliseconds to be: for a monopolar electrode, 0.5–4.5; for single-core concentric electrode, .05–4.3; for double-core concentric electrode, .03–2.6 msec.

Turning of the concentric needle often changes

the form of the action potential. In general, monophasic spikes become diphasic when the needle is turned 90 degrees. A negative spike would become positive when the needle is turned 180 degrees. According to Lundervold and Li,[75] the unipolar electrode is best for the study of single fiber action potentials, and the concentric needle electrode is superior for the study of motor units. They conclude that recording of the action potential directly from the muscle through a needle electrode is still the best available method for the study of muscle function. For the analysis of polyphasic units and of action potentials during strong contraction of the muscle, a concentric needle with either single or double core combinations is best.

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Case Reports

Case Report of a Quadruple Amputee

Barbara A. Davis, 1st Lt. AMSC

C. A., age 21, a Peruvian soldier, while on maneuvers on August 12, 1956, was injured by the accidental explosion of a grenade, sustaining severe injuries to all four extremities. He was hospitalized at Central Military Hospital in Peru for two years and ten months during which time it was necessary to amputate the right forearm approximately midway, the left arm above the elbow, the right foot, and the left lower extremity high on the thigh. Following the completion of all the surgical procedures, efforts were made to fit the patient with prostheses without success and his functional activities were limited to the use of various utensils held by the right elbow. Because of the difficulties involved in his rehabilitation, arrangements were made through military and diplomatic channels to have the patient transferred to Walter Reed General Hospital where he was admitted in August 1959.

On admission, his general physical condition was excellent. He was immediately started on general conditioning and preprosthetic stump exercise and training in the physical and occupational therapy sections. Following evaluation by the amputee clinic team, it was decided that the unsatisfactory condition of the left above-knee stump required revision and the right foot stump should be converted into a Symes amputation. The condition of the upper extremities was satisfactory and the upper-extremity prostheses were prescribed. Revision of the thigh stump and the first stage of the Symes amptuation were performed on September 10, 1959.

On September 29, 1959, the patient was ready to resume the exercise program. The left above-knee stump measured one inch from the perineum to the end of the femur and two inches to the end of the stump. Except for a mild flexion-abduction contracture of the left hip, there was normal range of motion in other joints. Muscle bulk and strength were generally excellent. By this time, the upper-extremity prostheses had been fitted, successfully checked out, and prosthetic training started. By October 5, the patient had mastered the operational control of the devices and was then started on training in more skillful and functional activities, utilizing painting, leatherwork, silver, copper tooling, and plastics. In a relatively short time he was capable of most upper-extremity activities of daily living except full toilet care.

From the Physical Medicine Service, Physical Therapy Section, Walter Reed General Hospital, Washington 12, D.C.

FIG. 1. "Have equipment—will travel."

On December 1, the second stage of the Symes amputation was completed. During the Christmas holidays the patient was given a three-week convalescent leave.

On January 15, 1960, he was presented for evaluation at the amputee clinic. (This clinic is held once a week and is attended by the orthopedic surgeons, physiatrists, physical and occupational therapists, and prosthetists. Its purpose is the evaluation of all amputees for prosthetic fitting. Prosthetic prescription and initial and final checkouts are accomplished in this clinic.) For the left above-knee amputation, a conventional prosthesis was prescribed, consisting of a quadrilateral wooden socket with a pelvic band, Bock knee, and SACH (solid ankle cushion heel) foot and ankle. For the right Symes stump a plastic laminated prosthesis with a SACH foot and ankle was prescribed (Fig. 1).

FIG. 2. Ambulation aid.

On February 4, both lower-extremity prostheses were delivered to the Physical Therapy Section. Gait training was initiated, and was carried out twice a day, each treatment period being increased daily according to the patient's tolerance.

In deference to the extremely short above-knee stump, extensive time was devoted to developing balance, movement, and control of the above-knee prosthesis. With initial attempts to walk in parallel bars it became apparent that, lacking the ability to grasp the rails with his hooks, some special means of providing stability and security was necessary. This problem was solved by the use of a sliding bar that was fitted across the rails of the parallel bars and which could be grasped with the patient's hooks. To this bar, a built-up armrest was attached on the right side, permitting the patient to help support his body weight on the right elbow at a height which, in addition, tended to maintain a tall posture and eliminated stooping (Fig. 2). This device, which was constructed by the Occupational Therapy Section, proved to be invaluable during this relatively brief but important phase of training. An additional difficulty encountered at this time was a tendency for the short above-knee stump to slip out over the posterior wall of the socket as the patient progressed from stance to toe-off on the prosthesis. This ultimately was overcome by the attachment of an elastic gluteal strap between the pelvic band and the posterior aspect of the socket.

By February 17, the patient was fitted with wooden axillary crutches. When ambulation with crutches was attempted, a threefold problem was encountered: (1) with the Dorrance hooks and bilateral upper-extremity prostheses, the patient was unable to maintain a secure grip on the crutches; (2) he was unable to use the crutches with shoulder depression; and (3) in the event of a fall, there was uncertainty as to whether he would be able to release and discard the crutches. This problem was presented to the Army Prosthetics Research Laboratory, and they devised safety handgrips with a break-away mechanism which enabled the patient to press down and immediately release his hooks (Fig. 3).

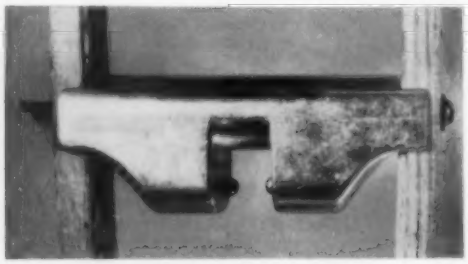

FIG. 3. Safety hand grips.

A four-point gait was used until the patient felt secure and his balance improved. He was then taught the three-point gait, using the left above-knee prosthesis as the third point. A small amount of circumduction with the above-knee prosthesis was noted. After several unsuccessful attempts to correct this in training, it was decided to remove one quarter inch from the left above-knee prosthesis. The circumduction was decreased. The patient made progress in sitting, standing, and in handling his crutches from these positions. He was taught to ascend and descend ramps, keeping his steps to a minimum size.

FIG. 4. Climbing stairs.

Throughout his training period, the patient was well-motivated and displayed a tremendous amount of courage and stamina. His balance improved notably. On March 23, he was able to pick up his crutches from the floor. This was performed by taking his weight on the Symes prosthesis, with the left above-knee prosthesis extended and leaning forward. The use of canes proved to be neither feasible nor safe. It was decided to use one crutch with the right prosthesis because it satisfactorily provided the stability the patient required.

The fear of falling was obviously a problem. The patient had been instructed to block a fall with the right shoulder and buttock. A few mock trials were attempted. On March 25, while ambulating with the cane, the prosthetic knee buckled and he experienced his first true fall. He was able to roll over and back himself up to a chair in a sitting position. With his right elbow placed on the seat of a chair, he pulled his body up into a sitting position on the chair. This experience increased his confidence.

He was taught to go upstairs sideways with the Symes prosthesis leading, using the left crutch. He leaned slightly forward and rested his right upper-extremity prosthesis on the railing (Fig. 4). He descended in much the same manner, leading with the left above-knee prosthesis and locking the knee securely. When rails were not available, he leaned his back against the wall and was able to ascend and descend by pushing his weight against the wall.

His gait training outdoors was started on March 28, and in a short time he was able to make his way over mud ruts, sand, grass, small obstacles, and curbs. As one observer remarked, the only thing that he could not master was climbing a ladder. On April 5, he was able to walk 56 steps per minute on a level floor.

On April 8, the patient was again seen in the amputee clinic when it was decided that he had received optimum benefit from training. Additional skill would come with time and practice. The prostheses were sent to the brace shop to be finished. Arrangements were started for his return to Peru. It is anticipated that he will be employed at a hospital in administrative work and will also assist in the training of other amputees.

The patient spent approximately two hours a day in physical therapy and two hours a day in occupational therapy. His full gait-training period in physical therapy was 10 weeks.

SUMMARY

The case history of an adult, quadruple amputee has been presented. The various problems encountered, and their solution, in the process of his physical rehabilitation have been presented. These emphasize the necessity for the cooperative efforts of the team approach as evidenced by the importance of (1) surgically adequate stumps, (2) proper prosthetic prescription, fabrication, and fitting, (3) prosthetic training, and (4) a well-motivated, psychologically prepared patient.

Suggestions from the Field

Two Temporary Braces For Adults

James W. Barbero, B.S.,
and Otakar Machek, M.D.

Many temporary braces and devices are described in the literature. In theory it would seem ideal to have a single adjustable brace that separates into independent long and short-leg components. However, this has been found impractical because of the complexity of the mechanical arrangement and a resultant instability. Therefore, separate short and long leg braces for adult patients were devised.

Description of Temporary Short-Leg Brace

The short-leg brace is a standard double-upright Klenzac appliance with a split stirrup. A stainless steel rollerskate-like clamp is welded to each split stirrup so that toe-up is ten degrees. This clamp holds the brace to the shoe by means of a single adjustable screw which passes under the sole of the shoe immediately in front of the heel. The corresponding nut is soldered to the clamp to prevent its loss. Figures 1 and 2 show clamp measurements, expressed in centimeters (cm.).

Mr. Barbero is Chief Therapist at Lutheran Hospital, St. Louis, Missouri.
Dr. Machek is Medical Director of the Physical Therapy Department.

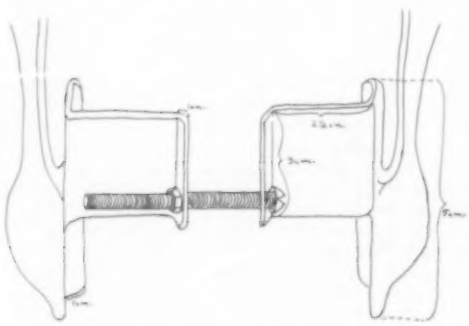

FIG. 1. Bottom view of shoe attachment.

The stirrups and uprights are 8.5 and 31.5 cm., respectively. The total 40 cm. length is non-adjustable. The uprights are bowed slightly more than usual, increasing the distance between the uprights, so that the brace will fit right or left legs. The circumference of the calf band is 22 cm. and the diameter is 11.2 cm.

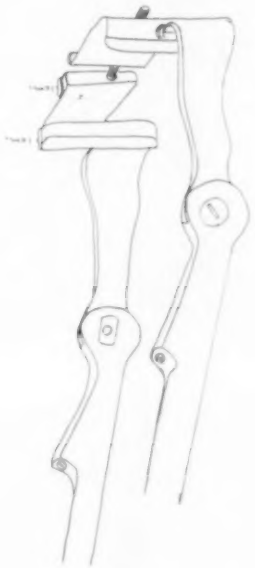

FIG. 2. Side view of shoe attachment.

Description of Temporary Adjustable Long-Leg Brace

The long-leg brace has two dependent components: the first is a rigid knee cage, and the second is a short-leg brace without a calf band (Fig. 3). The rigid knee cage is 38 cm. long. The circumference of the thigh band is 28 cm. and the diameter is 12 cm. Calf-band measurements are the same as for the short-leg brace. The calf band pivots along its transverse axis so that it will conform to different shaped calves. The knee cage is also bowed slightly more than usual.

The short-leg component has eight holes, eight millimeters apart, at the top of each up-

right. These holes fit over two sets of threaded posts five centimeters apart which are located on the knee cage uprights opposite the calf band. The eight holes of the short-leg component allow a total length variation of 4 cm. Four wing nuts are used to secure the drop-foot brace to the knee cage.

SHOES

We keep three sizes of surgical shoes in our department which are available to patients who have shoes unfit for bracing. Shoe sizes 5, 7, and 10 will fit the majority of adults. The surgical shoe works well because it is a leather high-top shoe that laces to the toes and fits easily on a swollen foot.

The clamp will fit any oxford shoe that has at least a 1.5 cm. heel, a 6 cm. or higher instep, and a sole not more than 1.2 cm. thick. If a shoe does not meet these requirements, the brace will fit poorly and will strike the floor when the patient walks. A cardboard wedge, or other improvisation, may sufficiently widen a narrow sole so that the clamp will fit. Temporary socks, for sanitary purposes, may be made from 3-inch stockinet (tubular type) cut to the proper length.

ADDITIONAL ADJUSTMENTS

Leather inserts are used to reduce the size of the calf and thigh bands. Insert size corresponds to the respective thigh or calf band and is held to the brace by a set of straps and buckles. A hand towel strapped behind the insert will reduce the circumference further. A one-inch webstrap with a buckle may be used as an improvised T-strap to control ankle supination and pronation.

COMMENT

These temporary braces are effective for many reasons:

1. The doctor and therapist have an opportunity for realistic observation and evaluation because the support given by the temporary brace resembles that of a permanent brace.
2. Debilitation due to bed rest is minimized because the patient can begin early standing and ambulation.
3. The danger of injury is reduced because of more adequate leg support.

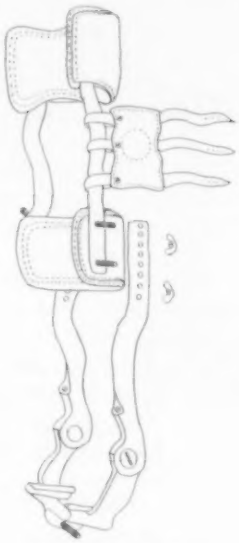

FIG. 3. Long-leg brace.

4. Temporary bracing will spare the patient the expense of a permanent brace if his recovery is rapid.
5. The immediate availability of a temporary brace shortens the training period.
6. This brace helps patient-acceptance of a permanent brace.

The braces have been successfully fitted on many patients by using the previously described adjustable features. Though we use our braces most frequently on hemiplegic patients, there is no reason to limit the use to this type of patient. The fact that the temporary brace alignment is not perfect may be a blessing in disguise. Obviously it is more difficult to walk with a temporary brace made to adjust to many patients than it is to walk with a custom made appliance. A patient will notice improvement of gait, stability, and comfort when he uses his own permanent brace. This is much the same principle that a ball player employs when he swings several bats before selecting one for batting.

ACKNOWLEDGEMENT: The authors wish to thank the B & H Orthopaedic Appliance Company for their suggestions and cooperation in developing these braces.

Editorial

We Are Forty

The proverbial expression "Life begins at forty" should have significance to us, for our Association will be celebrating its fortieth birthday during 1961.

On January 15, 1921, a group of young women, who had been known as Reconstruction Aides during World War I. and physicians with whom they had served, met for supper at Keen's English Chop House (still in existence) in New York City. For two years there had been an increasing interest among the Reconstruction Aides in various sections of the country to continue the ties which they had during their training and service for the restoration of the war injured. With the encouragement of the physicians and the enthusiasm of the Reconstruction Aides, the decision to form a national organization was made that night. During the next few weeks a constitution was drawn up, and letters were circulated for ratifying the constitution and electing officers. The objectives of the organization were forthright in expressing the following:

> "The purpose of this Association shall be to establish and maintain a professional and scientific standard for those engaged in the profession of physical therapeutics; to increase efficiency among its members by encouraging them in advanced study; to disseminate information by the distribution of medical literature and articles of professional interest; to make available efficiently trained women to the medical profession; and to sustain social fellowship and intercourse upon grounds of mutual interest."

In three months, the first issue of the *P. T. Review* was published; and by the end of the year 274 persons in 31 states and the District of Columbia had ratified the Constitution and become members. These former Aides became known as our Charter members; and the physicians who had encouraged the new organization were among the first Honorary members.

The handwritten minutes of the Executive Committee meetings during the early years of the Association reflect the sincerity of the founders, as well as their vision and anticipations for the future of a profession dedicated to serving the patient well in his physical restoration. Committees on Education, Legislation, and a Vocational Bureau were formed, and an Editor and Manager of the *Review* were appointed, evidence of the new association's function as a professional organization. Although our Bylaws have been amended and our Code of Ethics reinforced during the intervening years, the principles originally set forth by the Charter members still prevail.

Through the years nearly 14,000 physical therapists have been members of the Association. The early issues of the *Review* carried announcements of four courses in physical therapy; and now, at the beginning of 1961, there are forty schools offering approved courses in physical therapy. In 1921 only one state, Pennsylvania, had legal regulation of the practice of physical therapists, whereas today practice is regulated in 36 states.

The first annual meeting was held in 1922; and annual conferences, including business and scientific sessions, have been held every year but two since that time. Seminars, Institutes, and Workshops for increasing knowledge and improving performance have been sponsored or co-sponsored by the Association, either in conjunction with Annual Conference or by state or region. Numerous committees have been formed to establish and maintain standards, to study and solve problems, and to initiate projects and programs which affect the maturing of the profession.

Some of the problems that are confronting us today were recognized forty years ago. We can benefit by the experience of the past and the courage exemplified by our forebears. As we begin a new year, our fortieth as an Association, may we move forward with wisdom and integrity as individuals and as a group in enriching the life of our profession and fulfilling our responsibilities in serving mankind.

LUCY BLAIR
Executive Director

Adaptation: Passive or Dynamic?

The outstanding characteristic of our time is change. A ferment of activity is taking place in social, political, artistic, economic, and scientific areas. Catalysts of change, as we all know, are such factors as the rise in population, improved communications media, and widespread use of research technics in many fields. No matter in which direction we look, we find the world is not standing still.

Our own field of physical therapy has been affected by many developments in recent years. Among these have been basic changes in emphasis in patient care. For example, attention is being focused more sharply on physical treatment of disabilities of the central nervous system, with exploration of technics for influencing motor control through body position and sensory input mechanisms. The number of poliomyelitis patients has declined with the successful use of vaccines. Developments in the electronics field have led to new types of apparatus for use in treatment and research. The impetus of the second World War, with spreading concepts of the "team approach" and comprehensive patient care, has been an important factor. A new medical specialty group has emerged whose interests in patient care are in many ways close to those of the physical therapist. New attention on the political scene to the medical needs of elderly persons will no doubt lead to further changes in patterns of patient care in the future.

What does all this mean to us as individual physical therapists? Simply this: We each have a professional duty to keep abreast of developments affecting our work. Much has been said and must continue to be said about professionalism and professional status. These begin with the responsibility of the individual member to do his best job, to practice ethically, and *to keep informed*. Not only the clinical fields of medicine but the related basic sciences are undergoing radical change. Dr. Harrison's articles in this issue of the *Physical Therapy Review* afford us a fine opportunity to survey current material in the field of anatomy, where new tools for research, such as the electron microscope, have become available. As advances are made in basic and clinical sciences, pertinent material must be identified and effectively integrated wherever applicable to physical therapy. Only in this way can the field be strengthened.

As medical education itself is undergoing consistant revision to keep pace with new developments in patient care, we must be alert to changing needs in the training of physical therapy students. An excellent approach to exploring ways in which the physical therapist can best serve the patient and the physician is being made

in one of our teaching centers. Here, experienced physical therapists have been assigned on a full-time basis to pediatric, surgical and medical departments with the object of seeking out means by which the physical therapist can be most helpful in current treatment programs of these medical specialties.

A recent journal article, dealing with the political scene, stated: "The law of life is change, and adaptation is the condition of survival." This need not be interpreted as "passive" adaptation, in which we merely make the best of difficulties or discouragements and somehow move around them. Adaptive change can be dynamic and progressive if we look to the future and take the trouble to think about where we should be going, as individuals and as a group. We must continue to observe, to read, to learn, to explore, and to question. As individuals and as a group, we must do our utmost to grow, to meet our professional responsibilities—in short, to assure that our adaptation to the changing trends in medical care will be in the direction of progress, with optimum use of our training and abilities in the care of patients and in the development of our field.

MARIAN WILLIAMS, PH.D.
Associate Professor, Division of Physical Therapy
Assistant Professor, Department of Anatomy
Stanford University
Stanford, California

Letters

Dear Editor:

Re: "A Clinical Evaluation of Ultrasound by Use of a Placebo Technic," by Michael P. Roman *(Physical Therapy Review, September, 1960)*.

Not all of us can write like Hemingway or even compile a report with brilliance and technical clarity, hence, I shall not dwell on Mr. Roman's literary skill; but I cannot refrain from commenting on his report, as a study in general, and on your acceptance of his article for publication.

One of the most basic factors in any research project is the existence of a control group, or two groups, identical in all aspects save one—that to be tested. In choosing his methods of comparison, Mr. Roman introduces so many variables, I do not see how he could possibly expect anything resembling a result that one might describe as "accurate." The most outstanding violation is the use of other modalities—moist heat and therapeutic exercise, no less!—effective means of treatment in their own right, not to mention massage. This, in addition to a fact usually understood in cases dealing with human complaints, *i.e.*, not only are two individuals different, even with the same complaint, disease, or illness, but the disease or condition will also, differ, as will a person's reaction and evaluation of it. If this is not enough to complicate the intended comparison, we have the additional differences in reactions of individuals to various methods of treatment. How then does the author expect to prove a point to an intelligent, professional audience by using as confused a presentation as is published.

This paper is supposed to evaluate the effectiveness of ultrasound technics as compared to that of placebo. I do not believe it came anywhere near accomplishing this purpose.

Sincerely,
DONALD SHECHTMAN
1161 Shakespeare Ave.,
Bronx 52, N. Y.

Dear Mr. Shechtman:

In reply to your letter which was directed to the Editor of the *Physical Therapy Review*, concerning the article entitled "A Clinical Evaluation of Ultrasound by Use of a Placebo Technic," I submit this rebuttal. As the name implies, this paper discussed the therapeutic aspects of ultrasound on a clinical basis. Since ultrasound is most often used in conjunction with other modalities, I felt more than justified in including these modalities in this study. The other point mentioned in your letter concerning the subjectivity "in cases dealing with human complaints" was corroborated in my article.

Finally, you stated that "this paper is supposed to evaluate the effectiveness of ultrasound technic as compared to that of placebo," when the stated purpose of this paper was to "provide a subjective evaluation of the therapeutic effectiveness of ultrasound in the treatment of three conditions." The original purpose for undertaking this study was to stimulate constructive criticism of the therapeutic value of ultrasound in clinical situations. If I may consider your letter as one example of stimulated thinking, then I believe it is safe to say that my paper accomplished its purposes.

Sincerely yours,

MICHAEL P. ROMAN
Clinic Administrator,
Montgomery County Association for Physically Handicapped Children

Association News

Elsie R. Allis, of Springfield, Massachusetts, died in late August 1960. Miss Allis, a graduate of the Harvard Courses in physical therapy, became an APTA member in 1933. She was most recently on the staff of the Monson State Hospital, Palmer, Massachusetts. Miss Allis had always been a member of the Massachusetts Chapter, and at the time of her death resided in the Chapter's Western District.

Report of the Nominating Committee

The Nominating Committee met in the National Office on November 30, December 1 and 2, 1960, to select a slate of candidates to fill the offices of President, 1st Vice-President, 2nd Vice-President, Secretary, Treasurer, four Directors, and one member of the Nominating Committee. Election for these offices will be held during the Annual Conference in Chicago, July 2–7, 1961.

Previous to the meeting, chapter, districts, and individual members had submitted 146 names of persons to fill these offices. Thirty-nine were recommended for more than one office. Consent to serve was received from 95 persons, 29 declined, and 22 did not answer.

It is regrettable that of 108 component units (57 chapters and 51 districts) only 21 chapters and 16 districts submitted names. It is the privilege and responsibility of members through their chapters and districts to suggest the names of competent persons for consideration. It is the hope of the Nominating Committee that every effort be made to maintain and increase the interest of the chapters and districts to exercise this privilege.

The Committee gave serious consideration to a number of factors in considering and selecting the slate. These factors were qualifications of the individual for a specific office and participation in professional activities at Chapter, District, and National levels. To provide balanced representation, consideration was given to distribution of the membership geographically, to the size of chapters, and to the fields of physical therapy employment. In order to give fair consideration to these factors, the Nominating Committee must rely principally upon the information received on the recommendation and biographical forms. There were times when the information was inadequate, and the Committee appreciated the opportunity to meet in the National Office where information on candidates was readily available in the files.

CANDIDATES FOR ELECTION: 1961-1964

President:

Sarah W. Bassett, Boston, Mass.
Mary E. Kolb, Leetsdale, Pa.

First Vice-President:

Jean Bailey, Milwaukee, Wis.
Dorothy Page, Albany, N. Y.

Second Vice-President:

James Bauer, Storrs, Conn.
Frances Ekstam, Indianapolis, Ind.

Secretary:

Anna Janett, San Leandro, Calif.
Margaret Moore, Chapel Hill, N. C.

Treasurer:

Anthony DeRosa, White Plains, N. Y.
Robert Hickok, St. Louis, Mo.

Directors:

Majorie Ionta, North Weymouth, Mass.
Mary Lawrence, Phoenixville, Pa.
Gladdes Neff, Long Beach, Calif.
Thelma Pedersen, Norman, Okla.
Wayne Perdue, Omaha, Neb.
Kathryn Phillips, Warm Springs, Ga.
Edward Rathjen, San Jose, Calif.
Ruth Thvedt, Minneapolis, Minn.

Nominating Committee:

Alma Maga, Chicago, Ill.
Mildred Wood, Chapel Hill, N. C.
(after Sept. 1, Lexington, Ky.)

Nominating Committee:
Dorothy Baethke
Lloyd Hanson
Lorraine Paulson
Virginia Wilson
Ruby Decker, *Chairman*

Members' Publications

John Metz, District Nursing Association of Northern Westchester, New York, is co-author with Edward F. Delagi, M.D., and others, of an article entitled "Rehabilitation of the Homebound in a Semi-Rural Area," published in the *Journal of Chronic Diseases,* November 1960.

Chapter News

Arizona

The premier newsletter reports that "Maintaining Professional Leadership" was the October meeting topic.

Massachusetts

The surgical aspects of chemopallidectomy and the postoperative treatment of patients who have received the procedure were discussed by two physicians at the November Chapter meeting. Later in the month the Fall institute considered the subject of "Hips."

A lecturer on education presented "Introduction to Psychosomatic Medicine" at the December Chapter meeting.

New York—Greater New York District

Included in coming events for the District are two sessions on administrative problems in physical therapy. One session will be a panel discussion; the second session is entitled "Tax, Legislation, and Insurance."

Northern California

According to a newsletter item, members are requested to show the APTA membership card when registering at the Chapter meetings.

Pennsylvania

A "Pennsylvania Parade" article enumerates the Chapter's distinguished members as eight Life, two Associate, and two Honorary members. Other newsletter items include: listing of Chapter and District officers, report of the Conference Chairman, report of the Public Laws Committee, and information reply-form for the new directory to be entitled "Membership Guide."

Tennessee—Middle District

Dr. Lloyd M. Dunn, Coordinator of Special Education, Peabody College, Nashville, was the speaker at a District meeting. Recent research in the area of mental retardation was the subject of his presentation.

Texas

The dates of February 25–26, 1960, have been set for an institute on motor integration to be held in Galveston. Members of the teaching staff of the University of Texas Medical Branch and physical therapists will discuss: afferent stimuli to facilitate or inhibit motor activity; indirect training to facilitate motor activity; proprioceptive neuromuscular facilitation; and equilibratory reflexes in the treatment of cerebral palsy.

Wisconsin

The subject of conversion hysteria and malingering was discussed by a psychiatrist at the November Chapter meeting.

Marriages

Susan K. Babcock, of Milwaukee, Wis., now Mrs. Susan B. Sepic, Milwaukee.
Carlotta Baron, of Chicago, Ill., now Mrs. Carlotta B. Hoffman, Berwyn, Ill.
Sara J. Bedini, of Chapel Hill, N.C., to John W. Weaver, Chapel Hill.
Alice Bredehoft, of Kansas City, Mo., to James W. Buford, Kansas City.
Myrtis Brewer, of Erie, Pa., to John S. Banta, Kellnersville, Wis.
Kathleen Costello, of Long Beach, Calif., now Mrs. Kathleen C. Garrity, Long Beach.
Elizabeth Dennis, of Springfield, Mo., now Mrs. Elizabeth D. Mack, Springfield.
Joan Foster, of Montpelier, Vt., now Mrs. Joan F. Welch, Montpelier.
Shirley J. Francis, of Balboa, C.Z., to Carroll F. Anderson, Balboa.
Elaine J. Green, of Grand Rapids, Mich., now Mrs. Elaine G. Seymour, Honolulu, Hawaii.
Kristin Hallvardsdottir, of Bridgeport, Conn., to Harry Engel, Agaua, Guam, M.P.
Nancye Hertnick, of Rock Island, Ill., now Mrs. Nancye H. Dawley, Moline, Ill.
Amitta M. Holland, of Vallejo, Calif., to Frank F. Seebode, Murphys, Calif.
Sandra R. Holland, of New York, N. Y., to Fredric Margolis, New Bedford, Mass.
Ellynmae Hottenstine, of Biloxi, Miss., to Peter L. Hamilton, Elk City, Okla.
Dorothy E. Lueke, of Palm Springs, Calif, to Frank L. Demond, Balboa, Calif.
Phyllis Mader, of Baltimore, Md., to Gary G. Schiller, Cumberland, Md.
Catherine M. McCauley, of Collingdale, Pa., to Gerard J. Dalcourt, Collingdale, Pa.
Lena McGaha, of Knoxville, Tenn., now Mrs. Lena M. Brake, Knoxville, Tenn.
Barbara A. Poole, of Pennington, N.J., now Mrs. Barbara P. Rozema, Chicago, Ill.
Unni Sather, of Honolulu, Hawaii, now Mrs. Unni S. Dahlstrom, Honolulu.
Nancy J. Smith, of Detroit, Mich., now Mrs. Nancy S. Malpass, Albany, N.Y.
Suzanne Sublette, of Los Angeles, Calif., now Mrs. Suzanne S. Coomes, Los Angeles.
Sally Turner, of Raytown, Mo., now Mrs. Sally T. Crawford, Houston, Texas

New Student Members

College of Medical Evangelists

W. Lee Charboneau
Barbara L. Evans
Rodger E. Hirst
Eva J. King
Matthias Krebelder
Floyd L. Shephard
Linda R. Walker

D. T. Watson School

Sally J. Andrews
Lee V. Beatty
Anthony A. Borinsky
John D. Bowles
Charles G. Branz
Michael G. Brown
Charles M. Byers
Margaret M. Cramer
Nancy M. Curran
Dian Darby
Donald M. DeBald
Anthony Develli
Myra L. Fauly
Charles D. Gerald
Homer L. Greene
George G. Hazlett
Carl B. Henderson
Nancy J. Himmer
Howard E. Holland
Jean C. Ketterer
Jean A. Kohlhaas
Ann E. Liebschner
Sally K. Lovell
Elizabeth J. McMahon
Carla M. Miller
Lois A. Miller
Roland F. Selby
Raymond S. Serne
Hannah S. Stapler
Joanna Stipanovich
Patricia B. Strott
Marvella Webster
Marguerite M. Wells
Judith A. Young

Ithaca College

Carole S. Perelson
Gail A. Silverthorn

Marquette University

Judith A. Krison

Medical College of Virginia

Helen N. Alexion
Mary D. Blanton
Silas A. Butler, Jr.
Anna C. Collier
Gloria B. Ford
Bill J. Harrington
Linda J. Harwell
Jack L. E. Hines
Frances A. Hughes
Elizabeth E. Merrells
Ann H. Moloney
Harvey A. Moran, Jr.
Carol M. O'Brien
Elizabeth Shannon
Judith E. Staley
Noralie F. Stark
Martha E. Suter
Ann G. Sykes
Nancy O. Tanner
Mark K. Wenzel
Cora E. Wood
Grace E. Yoder

New York University

Philip A. Greenblatt
Richard B. Morone
Helen M. Strier
Joyce L. Thomas
Carol S. Weiner

St. Louis University

Mary C. Barnett
Carol E. Driscoll
Judith A. Foppe
Brenda Frese
Carol A. Gutterman
Marlene A. Heywood
Susan C. Meyers
Sr. Mary Aquinas Lyons
Michael W. Whelan
Ellen M. Wimberg

Stanford University

Alicia Ballentine
Barbara Carter

University of Connecticut

Doris A. Brownlee
Ruth I. Chastney
Patricia A. Cleary
Jean S. Davidson
Susan K. Drake
Bille C. Duch
Carol Edson
Mary E. Egan
Maretta G. Fessenden
Janis Gregors
Dawn Huestis
Nancy L. Johnson
Marilyn A. Koval
Diane R. Lacount
Virginia Langhorst
Joyce E. Marcustre
Janet A. McNeill
Marie C. Melluzzo
Nancy L. Oliver
Phyllis E. Oliver
Majbritt V. Peterson
Anne T. Pillsbury
Dorothy A. Reall
Carol E. Sawyer
Nancie E. Shuman
Marilyn L. Symes
Grace M. Whitehead
Carol L. Wilson
Barbara A. Woodward

University of Southern California

Rochelle Brucker
Kenneth J. Burton
Joan E. Henderson
Alan L. Hinds
Ayesha M. Hussain
Kay Kennedy
Frances J. Krebs
Ellen M. Levand
Doris E. Lyons
John R. Matthews
Wanita Pinnell
Brenda H. Quortop
Sharon A. Ryan
Armi Sarcoian
David A. Shields
Wayne W. Smith
Dennis L. Stahl

University of Wisconsin

Emily J. Gilley
Karen R. Vance
Karen G. Wenger

Washington University

Carole L. Coleman
Johanna I. McElwee
Linda B. Shannon
Margaret J. Singh
Helen L. Thompson
B. Renee Tweddle

Physical Therapy Fund, Inc. Announces Grant Award

The Board of Directors of the Physical Therapy Fund, Inc., is pleased to announce a grant award to the University of Pittsburgh School of Medicine to assist in a study of the effectiveness of various sensory stimuli in promoting muscular activity. The study is to be conducted in the Department of Physiology and Pharmacology under the direction of Leonard H. Cohen, Ph.D., Assistant Professor of Physiology, with the principal investigations by Helen Hislop, Ph.D., Research Associate of Physiology and Pharmacology. This is the fourth grant award announced by the Physical Therapy Fund, Inc.

The Physical Therapy Fund, Inc., a tax-exempt organization, was founded in 1957 with the purpose of providing funds to advance the art and science of physical therapy. Physical therapists and their friends have been consistent contributors to this fund.

PAST

PRESENT

FUTURE

Chicago • July 2-7 • The Palmer House

40th

ANNIVERSARY

Illinois Chapter

of the

American Physical Therapy Association

cordially invites

you

to attend the

38th Annual Conference

of the

American Physical Therapy Association

The Palmer House, Chicago

July 2-7, 1961

Rehabilitation and 90 Years

Many histories of Chicago often begin with the "Great Fire" of October 9, 1871. Where the fire started is clear; how it started, no one knows. The story commonly told is that Mrs. O'Leary, who occupied a house at Jefferson and DeKoven, often milked her cows by lamplight. At any rate, the fire department found an overturned kerosene lamp in the ashes of the stable and there is little doubt that the fire began there. The loss of property was estimated at $2,000,000. The fire destroyed a third of the city (about 18,000 buildings); and 100,000 homeless were aided by relief which poured in from all sides. New buildings, better than the old, soon went up; and one of the first large construction projects was the exposition building on the Lake Front where the Art Institute now stands.

Important events in Chicago in the 80's and 90's were the introduction of electricity in the form of light and telephone service, operation of the first cable car, the completion of the first Board of Trade building, and Hull House, founded by Jane Addams.

As the 400th anniversary of the discovery of America approached, the idea of celebrating with a great exposition took hold of the American people. The World Columbian Exposition took place in Chicago during the summer of 1893. The site chosen was Jackson Park, on the Lake Front. Over 27,000,000 people enjoyed a midway which highlighted reproductions of foreign villages, performances by Buffalo Bill and his Indians, and "Little Egypt," the hootchy-kootchy dancer, in the Midway's Streets of Cairo. The Ferris wheel was seen for the first time in America and proved a crowd favorite.

For a few years after the Fair, the city had its share of the Nation's financial troubles. Labor unrest broke out in two great strikes: the Pullman shop strike and the railroad walkout. Meanwhile, fortunes were crumbling and unemployment darkened the urban picture. But presently the clouds lifted and the new century came in to find Chicago ambitious for improvement. Notable events indicating this were: 1900, opening of the Drainage Canal; 1901, operation of electric railroads; 1906, first electric surface-

The Old Water Tower, sedate landmark of Chicago's near North side, survived the Great Fire of 1871 when 17,000 buildings were destroyed and 100,000 people were made homeless. Aid poured in from all sides to help the people to rehabilitate their city.

The 38th Annual Conference Masthead on page 52, depicting the "Past, Present, and Future," was designed by Theodore M. Conde, Hospitalman Third Class, Medical Illustrator Technician, U. S. Naval Hospital, Great Lakes, Illinois. The Illinois Chapter, APTA, and the *Review* are grateful for this contribution.

cars operated on Clark Street; 1908, elevation of 947 miles of railway tracks entering the city; 1916, Navy Pier completed; 1918, first air mail arrived; 1927, Municipal Airport opened; and 1933 and 1934 saw the realization of A Century of Progress Exposition, featuring a theme of applied sciences which lured almost thirty-nine million admissions in two years.

Following World War I, industry, stimulated by the demands of the war, boosted the city to the forefront in the international march of progress. Chicago, already a leading city in the production of steel, railroads, and in the meat packing industry, began its development as a great medical center, utilizing a network of city hospitals and research laboratories. Chicago's popularity increased as a convention city for professional groups and national political parties.

W. J. Showalter, former editor of *National Geographic Magazine*, has characterized Chicago as a city "situated in the very heart of the world's most fertile and prosperous valley, at the natural crossroads between the industrial East and the agricultural West, the ore-producing North, and the cotton-growing South. Possessing the cheapest water transportation on earth and the finest railway facilities in the world, it was inevitable that Chicago should grow; and it is equally inevitable that it will continue to grow."

With 27,000,000 admissions to the celebration of our country's discovery in 1893, 20 per cent of the total population was represented. Illinois Chapter looks forward to being host to the APTA's 40th Anniversary celebration in Chicago, and hopes that more than 20 per cent of the total physical therapy population will be present for the exposition the Chapter is planning. Illinois Chapter is not to be outdone by the planning committee of the Columbian Exposition. There won't be a Ferris wheel, but your wheels must turn toward Chicago—to The Palmer House—on State Street!

Original Papers for Conference

Members of the Association who have been working on special projects related to physical therapy procedures—research, clinical or laboratory; reviewing results achieved with a group of patients; adaptation or application of new methods of treatment; or any other subject which will advance the profession—should plan now to report their work in Chicago next July.

Two copies of manuscript, typed (double spaced), should be submitted to Dorothy E. Voss, Editor in Chief, *Physical Therapy Review*, by Apr. 1, 1961. The *Review* Editorial Board will select papers to be read by members and has the prerogative of publishing those papers selected. Members will be notified of the Board's decision not later than April 25.

Professional Advancement Day July 3, 1961

In keeping with and in recognition of the Association's 40th Anniversary, Monday, July 3, will be devoted to various activities which serve to advance physical therapy as a profession. Every member will find a portion of the program of importance to him.

Beginning at 9:30 A.M. a panel of members of the Board of Directors will briefly point up several ways in which we must work to promote our profession and to develop ourselves as professional persons. The subjects of concern will be standards of practice, continuing education, research, legislation, and state registration.

Following the panel presentation, group meetings for further discussion of the topics introduced by Board members will be held from 10:30 A.M. until 12:00 noon. For several years, Monday morning group meetings have provided for those interested in research, for Chapter representatives who work on legislative programs, and for members serving on State Examining Boards and Committees. These meetings will be somewhat shorter than in previous years, but will be no less interesting. Two new topics—continuing education and standards of practice will permit members to gather information on these areas of vital concern to the profession.

A highlight of the day will take the form of a luncheon in honor of Charter members of the Association. This will be an opportunity for every member to enjoy the presence and inspiration of the founding members and past leaders who can be with us.

The afternoon session will begin with the necessary and usual formalities followed by two speeches of note—a review of our past accomplishments, and our anticipations for the future.

Professional Advancement Day will be a momentous occasion for the Association, for the profession, and for *you*!

Something for Everyone in 1961

Are you interested in new approaches to old problems—and to new problems? Do you feel uninformed on the economic aspects of care after a patient has left the hospital? Is your background adequate to understanding the behavior of the aged person and the aging process? Have you wondered why certain patients respond poorly to treatment? Is the parent of the child a greater problem to you than is his handicapped child? Do you fully understand the whiplash type of injury? If you need answers to some of these questions along with information on many other subjects, you must come to Chicago.

The Conference Program Committee met in Chicago, November 10–12, 1960, and planned twelve scientific sessions of interest to all physical therapists. The Committee kept in mind the many interests and varied situations in which physical therapists find themselves—hospitals, rehabilitation centers, schools, home care programs, and out-patient centers. The needs of the physical therapist who treats children, the one who treats adult patients who will return to productivity at home or at work, the therapist who serves in the Armed Forces, and the therapist who cares for the aged and the chronically ill were considered.

During the 38th Annual Conference, physicians, physical therapists, and others will present an integrated program on after-hospital care. What kinds of programs are available? Which patients will benefit most from a certain program? What factors—economic and sociologic—demand consideration? Does the cost of care prohibit the patient from receiving physical therapy? Or, can those responsible afford not to provide for physical therapy?

Specifically, the first session will include a presentation on The Essentials and Objectives of After-Care Programs followed by a panel of three persons who will discuss programs for the pediatric patient, the employable adult patient, and the geriatric patient.

The second, third, and fourth scientific meetings will entail three concurrent sessions. On each of three days, one session will be devoted to the pediatric patient, one to the adult patient, and one to the aged patient. Thus, physical therapists may concentrate on and receive information according to their special interests. Several physical therapists will present various approaches to the treatment of specific conditions.

Subjects devoted to the pediatric patient include: causes of birth defects; cerebral palsy; congenital amputations; and medical conditions, including asthma and cystic fibrosis. Physical therapy in schools for the handicapped and behavior of the handicapped child will also be discussed.

The adult patients of concern will be those injured in traffic accidents who have suffered minor injuries. Special emphasis will be placed on injuries to the elbow and the neck. One entire morning will be given to whiplash injuries, with related anatomy and resultant pathology preceding discussion of treatment procedures by physical therapists. Behavioral causes of accidents and psychologic reactions to injury will be topics for another session.

With nationwide concern for the care of the aged and elderly persons in need of medical care, physical therapists, too, are increasingly interested in how best to serve this group of patients. The aging process—physiologic and behavioral aspects—deserve and will receive attention during one session. Treatment of patients who have hip fractures, cerebral vascular accidents, other circulatory problems, and osteoporosis of the spine will be presented. Various "homes" for the geriatric patient with the family's home as one, bear discussion in terms of physical therapy services.

A general session will close the program—the topic—who belongs where—and the cost of care. What is said on these subjects should assist physical therapists to aid in community planning for and the establishment of adequate physical therapy services for patients of all ages.

Index to Current Literature

ADMINISTRATION

Staff Evaluations: A Key to More Effective Performance. Earl W. Wolfe. J. Rehab., 26:19, July-August 1960

AMPUTATIONS

The Above-Knee Amputee. Alvin Slipijan. Indust. M. & S., 29:422-426, September 1960

Prosthetic Replacements for the Partial Hand Amputee. Robert G. Thompson. Indust. M. & S., 29:399-404, September 1960

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Degenerative Arthritis of Lumbar Intervertebral Joints: A Clinical Study. J. C. Wilson. Am. J. Surg., 100:313, 322, August 1960

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Ice Water as Primary Treatment of Burns. Alex G. Shulman. J. Am. M. Ass., 173:1916-1919, August 26, 1960

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Communication Problems of the Geriatric Patient. Atwood Hudson. J. Speech & Hearing Disord., 25:238-248, August 1960

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Value of Equivocal Signs in Neurological Disorders. M. A. Kennard. Neurology, 10:753-764, August 1960

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Physiotherapy in Pregnancy and Labour. G. Harding Brazier. Physiotherapy, 46:231-232, August 1960

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Pressure Caudal Anesthesia and Back Manipulation. J. Harold Brown. Northwest M., 59:905-909, July 1960

The Components of the Frozen Shoulder. W. A. L. Thompson. Bull. N. York Acad. M., 36:501-509, August 1960

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Auscultation of the Heart in Infants and Children. Robert F. Castle and Ernest Craig. J. Pediat., (supplement), 26:511-561, September 1960

The Correction of Clubfoot by Utilizing the Controlled Withdrawal Reflex. Maurice B. Furlong and George W. Lawn. Arch. Pediat., 77:317-334, August 1960

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Physical Medicine: I. Sources of Information. The Physical Therapy Prescription. John B. Redford. Northwest M., 59:773-776, June 1960

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Physical Medicine: III. Principles of Therapeutic Exercise. John B. Redford. Northwest M., 59:1022-1025, August 1960

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Character Defense Preference and Group Therapy Interaction. Carl N. Zimet, A. M. A. Arch. Gen. Psychiat., 3:76/168-83/175, August 1960

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Rehabilitation of Injured Workers—Its Legal and Administrative Problems. Samuel B. Horovitz. J. Rehabil., 26:14-18, July-August 1960

Selection and Placement of the Handicapped Worker. Harold E. Yuker, William J. Campbell, and J. R. Block. Indust. M. & S., 29:419-421, September 1960

Rehabilitation of Facial Structures. Kenneth Phillips. Am. Practit., 11:678-683, August 1960

Education

United Cerebral Palsy Scholarships in Physical Therapy

Since 1954, the American Physical Therapy Association has administered scholarships in physical therapy to undergraduate students through annual grants received from the United Cerebral Palsy Research and Educational Foundation. A total of 148 awards have been made; 29 within the 1959–1960 academic year.

A grant has also been received by the Association for the current school year. All AMA approved courses in physical therapy have been invited to participate in this year's program and 31 of them are doing so. The grant money is divided equitably among these curricula and each one is entitled to 68 per cent of its final year tuition costs. This amount can be made available to one or more final-year students who meet other necessary eligibility requirements.

SHORT TERM COURSES FOR GRADUATE PHYSICAL THERAPISTS

Title of Course	*Sponsor of Course*	*For Details Contact*	*Dates of Course*
Cerebral Palsy	The North Carolina Cerebral Palsy Hospital Durham, North Carolina	Lenox D. Baker, M.D. Medical Director No. Carolina C. P. Hosp. Durham, North Carolina	Courses arranged according to individual need—duration 3 months
Cerebral Palsy Technics of Treatment	Children's Rehabilitation Institute for Cerebral Palsy Reisterstown, Maryland	Christopher H. Wiemer Executive Director Children's Rehab. Inst. Reisterstown, Maryland	Jan. 2—Mar. 17, 1961 April 3—June 16, 1961 July 3—Sept. 15, 1961 Oct. 2—Dec. 15, 1961
Theory and Technic of Treatment and Care of Neuromuscular and Musculoskeletal Disorders	Georgia Warm Springs Foundation Warm Springs, Georgia	Robert L. Bennett, M.D. Director Ga. Warm Springs Found. Warm Springs, Georgia	Mar. 27, 1961— June 16 or Sept. 8, 1961 Sept. 25, 1961 Dec. 15, 1961 or Mar. 23, 1961
Technics of Neuromuscular Reeducation	California Rehabilitation Center Vallejo, California	Margaret Knott, Chief P.T. Calif. Rehab. Center Vallejo, Calif.	January 1 April 1 July 1 October 1
Graduate Physical Therapy Program	Rancho Los Amigos Hospital Downey, California	Chief Physical Therapist Rancho Los Amigos Hospital 7601 E. Imperial Highway Downey, California	2nd Monday in March to 1st Monday in Sept. 2nd Monday in Sept. to 1st Monday in March
Advanced Physical Rehabilitation Methods for Physical/Occupational Therapists	New York University Medical Center—Institute of Physical Medicine and Rehabilitation (in cooperation with New York University School of Education)	Edith Buchwald Lawton, Director, Postgraduate Education for Paramedical Personnel, New York University Medical Center, Institute of Physical Medicine and Rehabilitation, 400 East 34 Street New York 16, N. Y.	Feb. 24, 1961 Apr. 24—May 19, 1961
Neurophysiology in the Treatment of Neuromuscular Dysfunction (P. T. 511)	U. of So. California Physical Therapy Dept. University Park Los Angeles 7, Calif.	Margaret S. Rood U. of Southern California	June 12—30, 1961 Oct. 9—20, 1961

Title of Course	Sponsor of Course	For Details Contact	Dates of Course
Neurophysiological Response Mechanisms in Therapy (P. T. 521) Prerequisite P. T. 511	U. of So. California Physical Therapy Dept. University Park Los Angeles 7, Calif.	Margaret S. Rood U. of Southern California	April 10—28, 1961
Anatomy for Therapists (P. T. 502a)	U. of So. California Physical Therapy Dept. University Park Los Angeles 7, Calif.	Roxie Morris U. of Southern California	July 31—Aug. 25, 1961
Upper-Extremity Prosthetics	Post-Graduate Medical School & College of Engineering, New York University; & U.S. Office of Vocational Rehabilitation	Prosthetics Education New York University Post-Graduate Medical School 550 First Avenue New York 16, New York	May 15—26, 1961
	Northwestern U. and U.S. Office of Vocational Rehabilitation	Director of Prosthetic Education Northwestern U. Med. School 401 E. Ohio Street Chicago 11, Illinois	June 5—9, 1961
Lower-Extremity Prosthetics	Northwestern U. and U.S. Office of Vocational Rehabilitation	Director of Prosthetic Education Northwestern U. Med. School 401 E. Ohio Street Chicago 11, Illinois	Feb. 20—24, 1961 Mar. 27—31, 1961 May 22—26, 1961
	Post-Graduate Medical School & College of Engineering, New York University; & U.S. Office of Vocational Rehabilitation	Prosthetics Education New York University Post-Graduate Medical School 550 First Avenue New York 16, New York	March 13—24, 1961 April 10—21, 1961
Growth and Development	School of Allied Medical Professions U. of Pennsylvania and U.S. Office of Vocational Rehabilitation	Roslyn Schlansky Coordinator of Special Courses School of Allied Medical Professions University of Pennsylvania 3901 Pine Street Philadelphia 4, Pennsylvania	February 13—17, 1961

Proprioceptive Neuromuscular Facilitation Film

A 35 minute color film with sound is available to chapters and schools of physical therapy at a rental fee of $10.00. One copy of the film has been given to the Association by the California Rehabilitation Center. Requests from states east of the Mississippi should be directed to the American Physical Therapy Association, 1790 Broadway, New York 19, New York; rental is payable to the American Physical Therapy Association. Those west of the Mississippi should write to California Rehabilitation Center, 2600 Alameda, Vallejo, California; rental is payable to the California Rehabilitation Center. All requests should be submitted two weeks in advance of date of showing. Alternate dates are desirable since both copies may have prior bookings.

Guide To Graduate Education

Any physical therapist contemplating a program of advanced study is encouraged to inquire of several colleges or universities in order to find a program compatible with his interests and needs.

A wide variety of programs is available throughout the United States and Puerto Rico. The following list is indicative only of some opportunities in the universities which offer approved courses in physical therapy.

Some areas of major study on masters/doctoral level	*Location of course*	*For information/bulletin, contact:*
2-10	College of Medical Evangelists Loma Linda, Calif.	Keld J. Reynolds, Ph.D. School of Grad. Studies
1-2-3-4-5-7-9-10-11-12	Stanford University Palo Alto, Calif.	Rixford K. Snyder Director of Admissions
8	Division of Physical Therapy Stanford Med. Center	Marian Williams, Ph.D.
2-5-9-10-11	Grad. Div., Northern Section U. of Calif., Berkeley 4	Dean of Graduate Division
	U. of So. Calif., Los Angeles 7	
1-2-5-6-10-11-12	Graduate School	Milton Kloetzel, Dean
8	P. T. Department	Margaret S. Rood
	University of Colorado	
2	Medical Center, Denver 20	A. R. Buchanan, M.D.
8		Dorothy Hoag
10		C. A. Maaske, Ph.D.
5-9-11	Graduate School, Boulder	Office of Admissions
1B-5-9-11-12	U. of Conn., Storrs	N. L. Whetten, Ph.D. Dean, Graduate School
1A-2-3-5-6-8-9-10-11-12	Grad. Sch., Northwestern U. Evanston, Ill.	Mrs. Janet L. Green Secretary for Admissions
	Indiana University	
9-11	Grad. School, Bloomington	J. W. Ashton, Ph.D., Dean
4-5	Sch. of Ed., Graduate Div. Bloomington,	H. T. Batchelder, Ph.D. Associate Dean
2-10	Sch. of Med., Indianapolis	John Van Nuys, M.D., Dean
2-5-9-10-11-12	*State U. of Iowa, Iowa City	W. F. Loehing, Dean, Grad. Coll.
8	Children's Hosp.	Wm. D. Paul, M.D.
2-4-5-9-10-11	University of Kansas Lawrence	John H. Nelson, Ph.D. Dean, Graduate School
	University of Maryland	
1-3-5-6-7-9-11-12	Graduate School, College Park	For either: Ronald Bamford Ph.D.
2-10	Sch. of Med., Baltimore 1	Dean, Graduate School
	Boston U., Boston, Mass.	
1-2	Graduate School	Edward K. Graham, Dean
5-6	School of Education	Donald Hayes, Registrar
1-2-3-5-9-10-11-12	University of Michigan Ann Arbor	Admissions Office, Horace H. Rackham, Sch. of Grad. Studies

1—Administration
1A—Hosp. Administration
1B—Bus. Administration
2—Anatomy
3—Chemistry
4—Education including Guidance & Counseling
5—Education
6—Guidance & Counseling
7—Human Relations
8—Physical Therapy
9—Physics
10—Physiology
11—Psychology
12—Others

* Partial credit of basic Physical Therapy program towards masters degree *if* student meets Graduate School requirements.

Some areas of major study on masters/doctoral level	*Location of course*	*For information/bulletin, contact:*
1-2-3-5-6-9-10-11 8	The Graduate School U. of Minnesota, Minneapolis	Theodore C. Blegen, Dean Mrs. Ruby M. Overmann
1A-5-9-10-11	St. Louis University St. Louis, Mo.	Robert J. Henle, S.J., Ph.D. Dean, Graduate School
1A-1B-2-3-4-5-6-9-10-11-12	Washington University St. Louis 30, Mo.	Lewis E. Hahn, Ph.D., Dean Graduate Sch., Arts & Sciences
2-3-9-10-11-12	Columbia U. New York 27 Faculty of Pure Science Morningside Heights	Prof. Marshall Kaye
1-5-6-7-11-12	Teachers' College 525 W. 120 St. New York 27	Admissions Office 525 W. 120 St. NY 27, NY
	•New York U., New York 3	
2-9-10-11-12	Grad. Sch., Arts & Sciences	Office of Admissions
1-5-6-7-8-11-12	School of Education	Office of Admissions
2-9-10-11	U. of Buffalo, Buffalo 14, N.Y. Grad. Sch., Arts & Sciences	H. M. Woodburn, Dean
1-5-6-12	School of Education	Robert S. Fisk, Dean
1A-2-3-5-9-10-11-12	•Duke University, Durham, N.C.	Dean of Graduate School
1B-2-3-4-5-9-10-11-12	Grad. Sch., U. of N. Carolina Chapel Hill	George A. Heard, Ph.D. Dean
1-2-3-5-6-9-10-11-12	Grad. Sch., Ohio State U. Columbus 10	Dean of Graduate School
	University of Oklahoma	
3-4-5-9-11-12	Graduate College, Norman	For either: Dean of Grad.
2-10-12	Medical Center, Okla. City	Coll., U. of Okla., Norman
2-4-5-7-9-10-11-12	U. of Pennsylvania, Phila. 4	Grad. Sch., Arts & Sciences
2-3-10-12	Baylor U. Med. Center, Dallas, Tex.	For either: Div. of Grad. Sch.
2-3-10-12	Grad. Resch. Inst., Dallas, Texas	Baylor U., Waco, Tex.
2-10	U. of Texas—Medical Branch Galveston	Donald Duncan, Ph.D. Assoc. Dean of Graduate School
2-10	Medical College of Virginia Richmond 19	Ebbe Hoff, Dean Sch. of Grad. Studies
	Marquette U., Milwaukee 3, Wis.	
2-5-9-10-12	Graduate School	Lawrence W. Friedrich, S. J. Dean
8	PT Curriculum, Sch. of Med.	Beth Phillips, Director
1-2-3-4-5-7-8-9-10-11-12	Graduate Sch., U. of Wisconsin Madison 6	Dean, Graduate School 150 Bascom Hall

1—Administration
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12—Others

• Partial credit of basic Physical Therapy program towards masters degree *if* student meets Graduate School requirements.

Abstracts

Rehabilitation in Industry

G. Gingras and G. Gagnon (Université de Montréal, Montreal, Canada), CANAD. M. Ass. J., 83:217-221, July 30, 1960

The rehabilitation of the handicapped and the more efficient utilization of this manpower in industry are both a responsibility and an opportunity to those who shape personnel policies in industry: those in charge of industrial health and safety; physicians and paramedical personnel, specializing in rehabilitation; the community at large; unions; and the government.

Rehabilitation is an investment, and this underlying economic aspect has proved so sound that a number of insurance companies have adapted the rehabilitation approach to the settling of claims rather than the purely financial settlements which leave the injured persons with some money perhaps, but with their disabilities unchanged.

Physical training, industrial workshops, vocational training, and placement are all necessary steps in the process; all of them are interrelated and must be coordinated at the level of planning, as well as at the level of individual rehabilitation. Medical rehabilitation remains the cornerstone of this work, but must be integrated with industrial rehabilitation; otherwise, without proper placement, all efforts may be futile.

Recuperation of functions, substitution, and compensation are all geared to obtain maximum function not only of a damaged organ, but also of the whole patient. Rehabilitation must rely upon the contribution of psychosocial technics, industry, and the community at large; otherwise, the handicapped may experience enormous difficulties in trying to reach a satisfactory level of adaptation in a productive life.

Work efficiency does not depend on anatomic perfection, but rather on the ability of a worker to perform a particular job. Handicapped workers have repeatedly demonstrated that many of them can attain a level of functional rehabilitation that will enable them to cope with the demands of competitive employment.

One of the reasons often given by employers for failure to make use of handicapped workers is that their insurance rates may be increased if they hire disabled persons. It has been clearly shown that the accident rate is not increased when the disabled are properly placed.

The identification of general physical fitness with working capacity must gradually give way to a concept of abilities in relation to job demands.

The Iliopsoas Muscle: Its Importance in Disorders of the Hip and Spine

Arthur A. Michele (New York Medical College, New York), Ciba Clin. Sympos., 12:67-101, May–July 1960

The author postulates that the iliopsoas muscle, one of the most powerful muscles in the body, makes a substantial contribution to producing signs associated with various hip and spine disorders. The anatomy and kinesiology of the hip are outlined in detail, and diagnostic tests for iliopsoas tension are described and illustrated.

The diagnosis, pathology, and treatment of hip dislocations, diseases of the capital epiphysis, fractures, bursitis, synovitis, and arthritis of the hip joint are discussed and related to iliopsoas muscle tension. The role of the iliopsoas muscle and its relationship to scoliosis, spondylosis, and spondylolisthesis are presented in a similar format.

This article contains numerous, excellent illustrations.

Cineradiographic Studies of the Collar-Immobilized Cervical Spine

Malcolm Jones (Department of Radiology, University of California School of Medicine, San Francisco), J. NEUROSURG., 27:633-637, July 1960

Previous studies of movements of various cervtical segments show that flexion occurs first in the lower segment when the head is semi-extended, but it occurs first in the upper segment when the head is flexed. Extension occurs first in the lower segment when the head is flexed, but it occurs in the upper spine when the head is extended. Intervertebral discs are compressed anteriorly and they expand posteriorly on flexion, but they reverse their action on extension. Anterior gliding of the vertebral bodies occurs on flexion, and posterior gliding occurs on extension.

This is a study of devices for immobilizing the cervical spine to determine their effect on the cervical area. Patients with cervical collars of plastic, leather, felt-stockinette, and chin-occiput braces were observed by cineradiography.

The results of this study show that complete immobilization is not obtained by the felt-stockinette collar. The plastic collar produces somewhat more stability, due to the greater vertical dimension and stiffness. The chin-occiput brace permits forward head motion which allows flexion in the mid and lower cervical segments.

The height of the supporting device determines the fixation of the upper cervical spine through restriction of head motion. If immobilization of the cervical spine is necessary, then motion of the head also must be prevented.

This mobility of the cervical spine suggests that little support is obtained with the collar in place; but the relief afforded by the collar suggests that relaxation of the cervical musculature has been accomplished.

Neurologic Status of Three-Year-Old Children Originally Studied at Birth

D. Thurston, F. Graham, C. Ernhart, P. Eichman, and M. Craft (Washington University School of Medicine, St. Louis, Missouri; University of Wisconsin School of Medicine, Madison), NEUROLOGY, 10:680-689, July 1960

A study of the possible injurious perinatal experiences and consequent later developmental defects among 340 three-year-old children is reported.

The children were divided into three groups; those whose prenatal histories and births appeared to be normal; those experiencing fetal anoxia or postnatal apnea; and those experiencing a variety of "other complications" (i.e., prematurity, blood incompatabilities, and frank birth injuries). They were evaluated by measures of blood oxygenation, behavioral responses, and consideration of significant factors from overall history of pregnancy, delivery, and neonatal period. There were 191

"normal," 132 "anoxic" newborns, and 98 "other complications."

At the three-year-old age level, evaluations were based on personality, intellectual, and neurologic function of the type thought to be sensitive to brain damage. The examination took two to three hours. No knowledge of the child's classification was afforded the examiner who was the pediatrician in charge of the neurological services at St. Louis Children's Hospital. The results of the tests were then classified into normal, essentially normal, suggestive, and positive. The percentage of those children having histories of normal, anoxic, or "other complications" was then figured into the three-year test results. The statistical results are presented in table form.

In summary, it was determined that suggestive and positive findings are more frequent in children with a period of postnatal anoxia than in the normal. The premature child with anoxia or other complications presented a higher percentage of neurologic findings. There was no significant difference between normal-premature and normal-full-term groups. Supposedly normal deviations that might have significance for central nervous system function were evaluated. It was felt that at least one, unusual psychologic reaction was more frequent in the complicated groups than in the normal group.

Light Hypersensitivity: A Review

Richard J. Bartlett (Department of Internal Medicine, University of Michigan Medical Center, Ann Arbor, Michigan), UNIV. MICHIGAN M. BULL., 26:212-220, July 1960

Light hypersensitivity has been considered for many years to be of etiologic significance in a number of disease states. A review of medical literature indicates semantic confusion and ill-defined research.

The normal reaction to the sunburn spectrum of ultraviolet light (2900 to 3200 Angstroms) is erythema followed by pigmentation. The erythema is the visible reaction caused by dilation of the minute vessels in the corium. The exact reason for the dilation remains obscure and controversial.

Most authors agree that photosensitizing substances must be present in the skin of patients with hypersensitive light reactions. These substances act by means of two basically different mechanisms: phototoxicity and/or photoallergy.

Phototoxicity is an abnormal reaction to light, induced in the skin by substances or changes (not allergens) which, on appropriate exposure, result in irritation or tissue damage without previous sensitization. Two conditions are required: (1) a photosensitizer in the epidermis, and (2) exposure to wavelengths of light that will be absorbed by the photosensitizer.

Photoallergy is the probable etiology of the polymorphous light eruptions. Proantigen is present in the skin. After a suitable incubation period, antibodies are produced, and these alone provoke no visible response. The true allergic reaction is then appreciated on reexposure to light: Proantigen + Light + Antibody = Visible reaction.

The disease states associated with light hypersensitivity are prurigo aestivalis, solar urticaris, contact photodermatitis, drug photosensitization, porphyria, pellagra, and lupus erythematosus.

On the basis of presently available evidence, it is theorized that certain drugs act in a manner yet unknown to block the antigen-antibody reaction rather than to prevent the formation of antigen itself. A minority of investigators have found antimalarials to be useful in milder cases of light hypersensitivity.

The sun-screening preparations are naturally indicated, but with the knowledge that certain of these ointments are now known to be potent photosensitizing agents themselves.

There is a need for clarity in definition of terms, and for more valid research technics and clinical studies in this area.

Treatment of Fractures and Dislocations, 1950-1960

Thomas Quigley and Henry Banks (Department of Surgery and Orthopedic Surgery, Harvard Medical School, and the Peter Bent Brigham Hospital, and the Harvard Health Services, Boston, Massachusetts), N. ENGLAND, J. M., 263:391-397, August 25, 1960

Elbow. After injury to the elbow the sooner active motion can be achieved without aggravation of the original trauma, the better are the end results. Too early activity may contribute to periarticular hemorrhage and "myositis ossificans traumatica." Injection of hyaluronidase into traumatized tissues disseminates clot and edema fluid and may thus diminish this subsequent ossification. Aspiration of this complex joint may markedly reduce limitation of motion.

Fractures of the radial head may be classified into three groups. Linear fractures without displacement may be treated by simple aspiration and prompt mobilization within the limits of pain. Comminuted grossly displaced fractures indicate prompt, careful excision of the fragments and early mobilization. Total excision of the radial head is compatible with full elbow forearm function.

Fractures of the olecranon in which the fragments are separated by the pull of the triceps have been successfully reduced with internal fixation with a long, heavy, tapering vitallium screw.

The management of the shattered elbow, involving comminution of the distal humerus, fracture of the proximal radius or ulna, and, frequently, interruption of peripheral veins and blood vessels cannot be standardized. Results, whatever the method of treatment, are generally not good. A method of wide surgical exposure and sufficient internal fixation to allow early mobilization is presently being studied.

Monteggia fractures have been successfully treated with intramedullary fixation of the ulna, removal of the radial head, and early mobilization.

Dislocations can be disabling. They should be carefully reduced to avoid any further soft tissue damage or, if reduction is difficult, surgically explored before gross edema occurs. Early active motion is preferred to prolonged, uninterrupted immobilization.

Forearm. Open reduction and firm internal splinting afforded by intramedullary rods is now the treatment of choice. Bone grafting at the time of fixation may overcome the tendency of intramedullary fixation in a nonweight-bearing bone to produce distraction. Protection in a full-arm plaster for 12 to 16 weeks is essential. Fractures through the junction of the middle and distal thirds of the radius with an intact ulna are inevitably followed by severe deformity and disability if open reduction and firm fixation is not carried out.

Wrist. The Colles fracture is one of the most frequent wrist injuries seen in urban hospitals today. Severely comminuted Colles fractures are best treated by skeletal traction.

A frequent and potentially disabling fracture is that of the carpal scaphoid. Primary prolonged immobilization appears to have many advantages over operative treatment which should be reserved for those cases that fail to unit after 6 months of immobilization.

Hand. In injuries of the hand, only that part of the hand that must be splinted should be splinted in the position of function. Intramedullary fixation and skeletal traction allow maintenance of a fair degree of active motion while maintaining alignment.

Spine. Compression fractures of the low dorsal and lumbar spine uncomplicated by neurologic injury are usually treated in the young by plaster immobilization in hyperextension and exercise. In the aged, acceptance of deformity, removable support, and early function are compatible with good results. Fracture dislocation of the thoracic or lumbar spine without paralysis should ordinarily be stabilized by fusion. There remains controversy relating to spinal cord injuries over whether laminectomy should be performed and, if so, when.

Fracture dislocations of the cervical spine with or without cord involvement should be placed in skull traction immediately. After reduction, fusion may be performed to prevent future instability of the spine.

Undisplaced fractures of the pelvis are ordinarily treated initially by bed rest and then by early function. Displaced fractures of the pubic rami usually have associated fractures posteriorly or sacroiliac separations. Traction is an appropriate measure to prevent shortening under such circumstances. Internal bleeding and genitourinary injuries are frequently associated with these injuries.

A Simple Test of Coordination in the Fingers

C. Miller Fisher (Massachusetts General Hospital, Boston). NEUROLOGY, 10:745-746, August 1960

Severe disturbances of the fine motor activity of the upper extremity can be detected by one or more of the following tests: holding the arms outstretched; touching the index finger to the nose; rapid pronation and supination of the forearm; touching the thumb to each of the fingers; rhythmic opposition of the index finger to the tip of the thumb; patting and polishing movements of the hand; and handwriting.

The author states that in minor abnormalities it is difficult to judge the precision with which the maneuver is performed, or the movement is so elementary that it can be carried out satisfactorily even in the presence of a certain amount of neurologic deficit.

In the following test, the number of parts moved is restricted, and fair accuracy and good speed can be achieved only by normal persons. The test consists of tapping the tip of the flexed index finger against the thumb, opposite the distal knuckle as rapidly as possible.

If peripheral motor weakness is not the limiting factor, several different kinds of abnormality may be encountered—slowness, small excursion, irregular amplitude dysmetria, premature arrest, and total inability to carry out a single movement.

The principle value of the test is as a screening measure in the early stages of a neurologic illness. If the test is well executed it is unlikely that coordination will be found at fault in other tests. The great sensitivity of the test as an indicator of neurologic disturbances is attributable to the fact that the fine play of many small muscles with a large cortical representation is under observation.

Excision of the Trapezium in Osteoarthritis of the First Carpometacarpal Joint

A. H. G. Murley (Royal National Orthopeadic Hospital, London, England). J. BONE & JOINT SURG., 42-B: 502-507, August 1960

Osteoarthritis of the first carpometacarpal joint is common, occurring most frequently in women past the menopause. Symptoms are pain in the joint with use, a lesser degree of pain at night, and weakness of grip due to pain. Radiographic changes occur first at the medial part of the articular surface of the trapezium.

It is stated that physical therapy and radiotherapy have been advised; but no satisfactory evidence of consistent improvement has been reported. Splinting relieves symptoms and a light plastic splint is the most convenient for the patient. In advanced cases, surgical excision of the trapezium or arthodesis of the first carpometacarpal joint has been advocated.

The author reports his clinical and radiographic assessment of 34 patients who were treated for this condition by excision of the trapezium. The clinical examination included noting tenderness at the operation site and alteration of sensation, activity range, and power of opposition and abduction. The grip strength was measured by a dynamometer.

The power of abduction of the thumb was more reduced by operation than was the active range of abduction. Opposition was less affected than abduction. Grip strength is greatly reduced, but many patients considered themselves much better because the remaining grip was painless.

Damage to the radial nerve was the most frequent complication of the surgical procedure.

Cerebral Palsy: A Re-Evaluation

Peter Cohen (Department of Pediatrics, University of California School of Medicine). J. CHRON. DIS., 12:-265-272, August 1960

The California statewide cerebral palsy program includes specialized diagnostic centers, residence schools, special education and training facilities in public schools, medical and surgical care, and an institution for custodial care. The State Department of Education has the administrative responsibility for residence schools and diagnostic centers with medical supervision contracted with the University of California Medical Center. The State Department of Public Health handles case-finding, preliminary diagnostic examinations, and provision for hospitalization. The State Department for Mental Hygiene provides institutional facilities. The University of California Cerebral Palsy Diagnostic Center offers psychologic and pediatric examinations, also social work interviews for patients screened privately or by the local clinic of the Crippled Children Services. Orthopedic, neurologic, speech, and other consultations are available. Those evaluating the patient confer and make recommendations, under the coordination of the pediatrician. The Special Education Program of the State Department of Education provides special day schools for the handicapped, including education, physical, occupational, and speech therapy, with orthopedic and pediatric supervision. When a child cannot

benefit from the educational program he may continue preventive therapy, but he may be placed in a state institution. Some communities have sheltered workshops for older patients, which provide a social outlet and opportunity for financial gain. The Bureau of Vocational Rehabilitation Services tries to determine aptitudes and skills which can be developed for gainful employment. Recreational programs are hampered by transportation difficulties. Most of the older individuals are cared for in county hospitals for the chronically ill and state hospitals for the retarded.

The Cerebral Palsy Diagnostic Center referred certain children to the residence school for education and prolonged investigation, observation, and intensive therapy which was sometimes negated by difficult separation from home, lack of motivation, or severe physical and/or mental handicap. This group confirmed published statistics regarding associated handicaps. Convulsions occurred in 51 per cent of the group; visual defects, including refractive errors, strabismus, perceptual errors, and other defects were common, as well as hearing defects; speech difficulties affected 70 per cent of the group, particularly athetoids; and a very high percentage of mental defects were measured by serial evaluations. Negative emotional attitudes, particularly over-dependence resulting from parental over-protection and guilt feelings, affect prognosis adversely. Children wtih mild handicaps who continue indefinitely in a dependent school environment find it difficult to adjust to competitive society. Weaning such children is facilitated by having the special school on the same grounds as the regular school, so that they can attend ordinary classes and return periodically to the special school for medical observation. Many older cerebral palsied individuals are emotionally disturbed and lacking in social integration, responsible for family disorganization. Vocational adjustment was least successful in the physically handicapped with associated emotional problems. In order to reduce guilt feelings in the parents which lead to their overprotecting the patient, it is necessary to make an early determination of the facts relating to the handicap and to make the correct interpretation to the parents, thus freeing them of their guilt and fulfilling the potential of the cerebral palsied. Continued social counseling and traditional therapy are most essential.

Studies in Parkinsonism: Relationships Between Tone and Tremor in Parkinsonism and in Normals

Hirsh Wachs, Joel Brumlik, and Benjamin Boshes (Department of Neurology and Psychiatry, Northwestern University Medical School, Chicago, Illinois), J. NERV. MENT. DIS., 131:32-38, July 1960

The relationship between the clinical symptoms of parkinsonism, tone, and tremor, has been of interest for many years. Hughlings Jackson in 1896 described tremors as "rigidity spread out thin," and rigidity as "tremors run together." Extensive experimentation has been done in the interim, with some workers supporting and others disagreeing with Jackson's concept.

In this study, measurement of tone and tremor were made in 25 patients with Parkinson's disease and 18 normal adult subjects. Tone is described as a continued state of tension in a muscle recorded in dyne-centimeters of torque. This is measured by a "tonometer" in which a moving metal arm, to which the patient's arm is attached, is driven to and fro through a constant arc by an electronically controlled motor. Resistance to the motion of the arm is transmitted to strain gauges where it is amplified and recorded. The recordings may then be converted into absolute physical units. Tremor is measured by a variable reluctance accelerometer, a small (2.5-gram) electronic device attached to the patient, which will measure low frequency vibrations and acceleration and transmit them to an electronic amplification and recording system. Seven parameters of tremor were described: frequency regularity, amplitude regularity, frequency, amplitude periodicity, abrupt wave-form change, harmonics, and spindles. The records of parkinsonian tremor were correlated subjectively and by statistical correlation of each parameter of tremor with torque tension. A significant degree of correlation was shown for all except amplitude periodicity. In normal subjects, no counterpart for tremor exists for six of these seven parameters. Tremor frequency was, however, correlated with torque tension in normals. It was found that in the normal person, as tone increases, tremor frequency also increases; whereas in the parkinsonian patient, the reverse was true, with a very significant decrease in frequency of tremor as tone increased.

It was further seen that abnormalities of tremor may or may not be associated with hypertonus, but that hypertonus is always associated with tremor of the parkinsonian type.

These findings conflict with Hughlings Jackson's observation and appear to indicate that "tone and tremor in parkinsonianism are separable; but when present in the same patient there is mutual interaction and modification in direct qualitative relationship."

Effect of Short Bouts of Isometric and Isotonic Contractions on Muscular Strength and Endurance

Walters, C. E., Stewart, C. L., and J. F. LeClaire (Department of Physical Education and Recreation, Florida State University, Tallahassee), AM. J. PHYS. MED., 39:131-141, August 1960

This study was prompted by the conflicting reports in the literature on the variations of the Hettinger and Muller method of strength development, its apparent lack of retention, and the unsolved problem of the specificity of strength development.

Isometric exercise with maximal resistance was compared with isometric exercise at two-thirds maximum resistance. Each of these was also compared with rapid isotonic exercises at a one-third maximum load. The preferred arm was exercised. The purpose was to study the effect of the three methods upon strength and endurance in the preferred arm and in the contralateral (unexercised) arm. A further purpose was to study strength development by the isotonic method when measured by an isometric test, and endurance by the isometric methods when tested by isotonic measures. Finally, the authors wished to investigate the retention of the effects of exercise by the three methods.

The elbow flexors of three equated experimental groups were used. A tensiometer was used for the isometric exercises and a plate-loaded dumbbell was used for the isotonic exercises. The training period was eight days, with forty-five seconds of exercise on each day. The preferred and non-preferred arm were tested isotonically and isometrically before the study, immediately following, three weeks later, and, finally, eight weeks later.

The results led to these conclusions: (1) all three methods are effective in the development of strength and its retention; (2) the full isometric method is more effective in strength development than the two-thirds maximum isometric method; (3) there is a tendency for both the preferred and non-preferred arm to gain in endurance; (4) the strength of the non-preferred arm is increased in all three methods; and (5) improvement, as measured by one method of testing, is not dependent upon the method of training.

Studies of Body Image in Men With Spinal Cord Injury

Hirsh Wachs and Misha Zaks (Department of Neurology and Psychiatry, Veterans Administration Hospital, Hines, Illinois), J. NERV. MENT. DIS., 131:121-127, August 1960

Body image is a generalized term referring to the image of one's own body which the individual has evolved through experience. It is concerned with feelings and attitudes toward one's body based on subjective experiences with it, and the manner in which the individual has organized these experiences. One would suspect that the patient with spinal cord injury, who has suffered a sudden loss of lower limb function, bladder, bowel, and sexual function, would have notable disturbance of body image.

The "Draw-a-Person" test appears well-suited for a study of such changes, and has been widely used by other workers for evaluation of paraplegics and other patients. Findings have been somewhat contradictory. One investigator reports that the majority of paraplegics drew figures without legs; another investigator reports that the patient with functional loss, such as the paraplegic, has greater difficulty in facing reality than does the amputee whose loss is structural. Other workers, however, have reported that there is no increased incidents in psychosis, and that even neuroses are uncommon.

In this study, the experimental group consisted of thirty adult male patients with traumatic spinal cord lesions, all of whom had impairment of bowel, bladder, and sexual functions; and thirty control patients who had no impairment of these functions, but whose length of hospital stay, age, and education were comparable to the paraplegic group. All of the control patients had a severe chronic disease.

Subjects were asked to draw a person, and then to draw someone of the opposite sex. Questions were then asked about the male figure (designed to elicit information about the adequacy of the figure, his family status, and the future plans and fate of the figure). Upon detailed analysis, it was found that the paraplegic group showed a tendency toward more anxiety and greater dependency on the environment, especially on the female figure. In other respects, however, whereas both groups differed from previously reported responses of "normal" subjects, there were no significant differences between the paraplegic and the control groups in body image. The failure to find pronounced differences between these two groups may be a reflexion of the general degree of disturbance in psychological functioning of any chronically ill patient.

Maintenance of Ambulation in Childhood Muscular Dystrophy

P. J. Vignos, Jr. and K. C. Archibald (Department of Medicine, Western Reserve University School of Medicine, Cleveland, Ohio), J. CHRON. DIS., 12:273-290, August 1960

Loss of muscle power is not the sole explanation for the sometimes premature transition to bed and wheelchair status in cases of progressive muscular dystrophy. A five-year analysis of 60 patients reveals many complicating elements which accelerate and precipitate the transition. Manual muscle testing with percentage grades were used to total and graph strength. Usually, strength was the same bilaterally. Goniometry revealed limitation in elbow, hip, and knee extension, hamstring and iliotibial band length, and ankle dorsiflexion. Rating scales for contractures, functional ability, and emotional factors in ambulation were devised. Retrospection on the cause for loss of ambulation in 25 per cent of the group reveals that symptoms of weakness appeared by age six in nearly all. All were wheelchair bound by age 11. Early comprehensive medical management prevents early chair confinement. Of those ambulating independently in double-upright long-leg braces, the period from appearance of weakness until loss of independent ambulation was 50 per cent greater than for the wheelchair bound. The period of expected independent ambulation should be at least 6 years from onset of symptoms.

Decrease in physical activity does does not correlate directly with loss of strength because children anticipate future lower functional status and thereby decrease physical activity prematurely. Three hours of standing daily is the best method for controlling flexion contractures. Bracing is indicated when the child spends less than a half hour standing daily or when there is rapid progression of knee contractures.

Acute traumatic injury and bed rest during medical illness often end ambulation. Prolonged inactivity causes disuse atrophy and favors rapid progression of contractures. Four weeks of chair confinement are generally irreversible. Any illness or injury that requires the dystrophic child to be off his feet more than 3 days requires mandatory institution of exercises to preserve strength, including standing to preserve equilibratory adjustments and to stretch joint contractures, with a light walking cast used for fractures. Slight increase in weight when the child reaches the critical stage, where there is just enough strength for precarious walking, limits independence. Weight gain occurs because food intake exceeds reduced energy demands. Psychic overeating and pampering discourage weight reduction. School authorities may place the ambulatory child in a wheelchair to prevent injury and to facilitate handling, thus hastening contractures, weight gain, and physical and emotional dependency. Social isolation and cessation of intellectual growth accompany withdrawal from school. Patients react to muscular dystrophy with great anxiety centered on a marked fear of falling. Poor home adjustments are common. Serious and prolonged periods of self-immobilization follow separation from a loved one, birth of a sibling, or hearing a frightening description of the clinical course of the disease. Passivity and depression, coupled with lack of motivation for walking, and poverty of expression make communication difficult. Personality markedly improves when the patient resumes walking after surgery and bracing. Systematic physical and occupational therapy, orthopedic surgery, psychiatry, and medical guidance may mitigate premature physical, psychological, and intellectual deterioration. Ade-

quate management of the extramuscular factors in muscular dystrophy is very important since it is not possible at present to influence muscle degeneration.

Fractures of the Hip: Immediate Versus Delayed Treatment

P. F. McGoey and John Evans (Toronto, Canada), CANAD. M. Ass. J., 83: 260-263, August 6, 1960

Early splinting of fractures has been the accepted aim of treatment for centuries. This survey was done to determine if the mortality figures in adult hip fractures of the neck and intertrochanteric areas improved by "emergency operations."

At St. Michael's Hospital in Toronto the mortality rates were studied in a series of 737 patients with fractured hips treated over a ten-year period. Of the patients studied, 182 were treated as acute emergencies. Vitallium Smith-Peterson nails were placed in intracapsular cases; and McLaughlin plates were added in the intertrochanteric fracture cases. The remainder of the 737 patients were treated in the routine manner, with surgery performed after admission to the hospital.

There was no significant difference in ages or sex between the two groups of patients.

The results of the study indicated that immediate operations appeared to reduce the in-hospital mortality rate. An aggressive policy of management shortened the duration of hospital stay appreciably.

Arterial Lesions of the Upper Extremity: A Clinical Review with Illustrative Cases

James D. Hardy (Department of Surgery, University of Mississippi Medical Center, Jackson), AMER. SURG., 26:525-547, August 1960

Much progress has been achieved in the field of arterial surgery. Optimal therapeutic results can be achieved only if surgically remediable lesions are carefully observed and diagnosed early.

Chronic shoulder, arm or hand pain may be a symptom of certain vascular lesions. However, differential diagnosis must be made between these vascular lesions, certain nerve lesions, and miscellaneous conditions such as cervical osteoarthritis, bursitis, and referred pain from the diaphragm, heart, or biliary tract. Finger necrosis may occur in all vascular lesions except in true aneurysm, reflex neurovascular dystrophy, and rarely in Raynaud's disease.

The primary objective in discussing this group of conditions and the symptoms was to emphasize the importance of careful observation. In recent years there has been better differentiation of the diseases that result in ischemia of the tips of the fingers.

Arterial lesions of the upper extremity are generally representative of arterial lesions elsewhere; but certain of these are peculiar to the arm.

Major gangrene is not often associated with arterial diseases of the upper extremity since the collateral circulation is extensive. Nevertheless, such diseases can produce far more physical disability than is commonly appreciated.

The range and, in some circumstances, the complexity of subclavian, axillary, brachial, and more distal arterial pathology have been emphasized.

Observations on the Measurement of Joint Stiffness

Verna Wright and Richard J. John (Applied Physiology Division, Department of Medicine, Johns Hopkins University School of Medicine and Hospital, Baltimore, Maryland), ARTHRITIS RHEUM., 3:328-340, August 1960.

A review of the literature has shown that little has been done to measure joint stiffness quantitatively and nothing has been done to measure it qualitatively. Previous methods have measured the subjective feeling of the patient, the limitation of motion measured by the observer, and the strength of grip.

The authors offer a method for the measurement of joint stiffness and the results of a study of joint stiffness in normal subjects and patients with connective tissue disorders.

Of the various factors influencing joint stiffness—elasticity, viscosity, friction, inertia, and plasticity—the authors' work has shown that the most important components are elasticity and plasticity. With elasticity, the stress (deforming force) is a function of the strain (deformation). Plasticity is characterized by stress relaxation and creep. If a plastic substance is stretched a given length, the force to hold it there melts away with the passage of time, (stress relaxation); and conversely, if it is stretched with a given force there is an initial rapid increase of length followed by a further gradual lengthening (creep). Viscous stiffness is small and friction is negligible even in badly damaged joints.

The major part of elastic and plastic stiffness is due to the application of the tendons and the joint capsule. This changes the concept that the joint capsule is a discrete structure as the tendon sheaths are an integral part of the capsule.

The authors are developing a simplified device which will give clinicians investigating patients on various drugs an objective method of measuring stiffness.

The Planning of Hospital Physiotherapy Departments with Special Reference to Therapeutic Pools

M. J. McMain (Superintendent Physiotherapist, Harlow Wood Orthopedic Hospital, near Mansfield, Notts, England), PHYSIOTHERAPY, 46:223, August 1960

This very detailed and comprehensive discussion of departmental planning begins with suggestions as to the location and structure of the general department, including suggestions on space needs in corridors, storage, doorway size and construction, heating, lighting, and the need for floors and walls adequately reinforced to support essential equipment, non-skid floor surfaces, suitable decorations, and properly placed telephones. The units to be included in a physiotherapy department are listed and described, with special remarks on ideal treatment rooms (three cubicles per therapist, with two electrical outlets at convenient height), the children's treatment room, and the gymnasium.

Suggestions are made in great detail regarding therapeutic pools. The pool room itself is described, including non-skid sidewalks at least 50 inches wide with covered gutters, and a hoist operated, if possible, on water power with conveniently located controls. Showers for

both ambulatory and stretcher patients, a cooling room for post-treatment accommodation to normal temperatures, linen rooms with warming racks, a drying room, staff changing rooms, office, and small adjacent treatment room are also discussed.

Problems of maintenance and suggested solutions are discussed for lighting, cleaning, agitation of water, and wear on underwater apparatus, water supply, and decorations.

A final word on the need for orderlies to relieve the professional staff of the many housekeeping and patient preparation duties completes this truly encyclopedic study.

Rehabilitation of Patients with Hip Fracture—A Clinical Study of 126 Cases

Masayoshi Itoh and Michael M. Dasco (New York University School of Medicine, New York), POSTGRAD. M., 28, 138-145, August 1960

Subsequent to definitive orthopedic care, 126 hip fracture patients were treated on whom data was collected between January 1951, and April 1957. All were treated in the Physical Medicine and Rehabilitation Department of the Goldwater Memorial Hospital of the New York University Medical Center. Patients without functional disabilities and those in whom severe medical complications contraindicated rehabilitation treatment were excluded. A variety of hip-fracture classifications were included. Eighty per cent of the cases were female; only two per cent of these were negro. Ages ranged from 38 to 95 with an average age of 65. Analysis of the location of the accident in which fracture was sustained showed 18 per cent to have occurred in nursing homes or homes for the aged, a figure felt to be indicative of the need for more stringent safety measures in these institutions. Seventy-five per cent of the cases were treated by surgery, 25 per cent requiring a second procedure such as removal of a Smith-Petersen nail. Incidents of complications were high. One of the most common, leg shortening, was felt to be responsible for both gait disorders and subsequent back pain. Pain was another common problem requiring careful analysis and treatment.

Following comprehensive rehabilitation with occasional use of appliances, such as elevated shoes and ischial weight-bearing braces, the following results were seen: 65 per cent were classified as totally self-sufficient in performing essential activities of ambulation, elevation, transfer, with or without crutches; 17 per cent were rated partially self-sufficient, requiring minimum aid; 9 per cent completely dependent, requiring considerable assistance; and 4 per cent were not fully analyzed. Whereas the degree of functional restoration was highest when union was good, 22 per cent of the total group became fully independent despite mal-union.

Use of a wheel chair should be limited to patients in whom severe weakness, intractable pain, cardiac disease or other complications make it really necessary.

Six months was felt to be an average period for the elderly patient without complications to achieve sufficient callus formation to permit resumption of activity. Unfortunately, many patients were not referred for rehabilitation until long after the optimum early treatment period.

Many patients often thought to be unsuitable candidates for rehabilitation due to mal-union, age, and other factors, were found to achieve a high degree of independence. For maximum effectiveness in such a program there is a need for early referral, maximum control of chronic medical problems, and consideration of individual social-economic needs.

Treatment of Fractures and Dislocations, 1950-1960

Thomas Quigley and Henry Banks (Department of Surgery and Orthopedic Surgery, Harvard Medical School, and the Peter Bent Brigham Hospital, and the Harvard Health Services, Boston, Massachusetts), N. ENGLAND, J. M., 263:344-349, August 18, 1960

Because of the rise in horsepower and the lengthened span of life of man, the number of fractures has increased 39–54 per cent. The care and treatment of these injuries becomes the responsibility of the medical profession.

The Patient. For every patient a course must be charted between rest and activity. As soon as possible in convalescence every muscle that can be moved must be actively exercised. The patient who sees continuous daily improvement is happy and will probably achieve good function and economic and mental self-sufficiency.

Fractures in Children. From a surgical point of view children are not small adults. Until the closure of the epiphysis, fracture problems in children are different from those in adults. Open reduction on children is condemned.

The Wound. No method has been learned as to how the process of would healing can be accelerated. Some experiments on dogs by Clayton and Weir have established the fact that divided ligaments at the knee heal with greater strength and function when sutured than when allowed to retract and bridge the gap with scar.

No exact rules can be promulgated. In general, precise surgical reconstruction will result in the best function. On the other hand, risks of operations on fractures are still great. Very good results for hundreds of years have followed intelligent application of closed reduction and splinting, or traction.

The Clavicle. Non-union of the clavicle is rare because the musculature of the shoulder girdle and neck tends to keep the fracture faces in contact. The traditional figure-eight splint does not immobilize, but does tend to counteract upward bowing of the clavicle. Intramedullary fixation is rarely indicated. In any treatment of a fractured clavicle it should not be forgotten that absence of the clavicle is compatible with perfect or nearly perfect function.

Acromioclavicular Dislocation. If the injury is to the joint capsule, a simple strapping with a sling is adequate. Some degrees of cosmetic asymetry may occur. But real disability is almost unknown.

If the injury is to the clavicular origins of the deltoid and trapezius muscles, apparatus to press downward on the clavicle and upward on the humerus is worthwhile.

If the injury is to the coracoclavicular ligaments, surgical repair is justified. An operation found satisfactory in this case consists of removal of the distal end of the clavicle and suture of the conoid and trapezoid ligaments with silk or fascial strip between the clavicle and the coracoid process.

The Shoulder. The problem in dislocation of the shoulder is the same today as 10 years ago. In 38 per cent of these cases the dislocation recurred. Of the many surgical procedures on record for recurrent shoulder dislocations, the litera-

ture in the past 10 years has favored the Bankart or Putti-Platt.

The Humerus. Comminuted fractures and fracture-dislocations of the articular surfaces of the humeral head may be very disabling. Vitallium replacement arthroplasty of the humeral head has good reports, but it is too early to evaluate this procedure. Undisplaced fractures of the surgical neck are best treated symptomatically and with very early active motion. Displaced surgical-neck fractures may be treated in many ways: closed reduction, traction, and open reduction.

Fractures of the shaft of the humerus are often regarded too lightly. They can present severe problems. They can be treated safely by closed reduction and immobilization. There have been good results with the hanging cast. Intramedullary fixation and bone grafts have been worthwhile.

Analysis of the Temporal Components of Motion in Human Gait

K. U. Smith, C. D. McDermid, and F. E. Shideman (Department of Psychology, University of Wisconsin, Madison), AM. J. PHYS. MED., 39: 142-151, August 1960

By means of an electronic motion analyzer (electrobasometer) precise values for the time components in gait under various circumstances have been obtained. In the method described, the subject, who may be shod or unshod, walks a divided brass runway. Foot-contact activates relays which control timing devices. The duration of foot-contact and stride-time for each foot or for both feet can be measured. The method permits the timing of the contact of any point on the sole or the whole sole.

Values were obtained for bipedal contact-time and for contact and travel time at different paces, with and without shoes, and in running. Sex differences, the effects of age, and the effect of carying a weight were also studied.

The authors point out that the method permits, for the first time, accurate, quantitative specification of motor coordination in gait, in terms of the correlation between contact-time and stride-time and in terms of indices of motor coordination derived from ratios between contact-time and stride-time. They cite the method also as a means of quantitating pathological gait. They have derived an index of locomotor movement coordination which they call the gait rhythm ratio. Norms for this ratio and for each of the various circumstances of gait were computed.

Some of the conclusions from the several studies reported were as follows: 1. The contact-time of unshod walking at normal pace is 0.70 seconds and the stride-time is 0.40 seconds. 2. Stride durations in men and women are not significantly different but the contact-time of the whole sole for men is longer than for women. 3. Wearing of shoes increases contact-time but does not increase stride-time. 4. Sole contact in walking is about double that of running, but stride-times are not significantly increased in running. 5. The time of either contact or travel shows no alteration between 4½ and 50 years of age. 6. The time pattern is unaffected by weights of 25 pounds or less. 7. Gait is not mechanically related in a highly consistent way to either weight or height.

The paper also includes a description of a portable electrobasometer for clinical, field, and laboratory use. Some of the circuits are diagrammed.

Muscles of Respiration and Speech: Annotations

(Adams St., Adelphi, London), LANCET, LOND., 2:637-638, September 17, 1960.

This article discusses the newer concepts in the kinesiology of the muscles of respiration and speech.

It is generally assumed that the intercostal muscles, as well as the diaphragm, take part in normal, quiet respiration and that expiration is passive. Clinical experience shows that respiration can be maintained without active diaphragm movements. From the way in which the intercostal muscles attach to the ribs, it was believed that the external intercostals raise the ribs and increase the diameter of the thoracic cavity, and thus act as inspiratory muscles; and that the internal intercostals are used only in vigorous expiration or to maintain the distance between individual ribs. These same muscles and others must also be concerned in the precise regulation of expiration necessary in speaking and in such occupations as playing wind instruments.

Through studies and experiments, it was found that in quiet breathing, the diaphragm is almost wholly responsible for inspiration and that action potentials appear in it before the inward flow of air begins. The external intercostals are not used in quiet respiration, but an upper part of the internal intercostals is used. A lower part of the internal intercostals contracts during expiration. Diaphragm activity does not cease until some time after expiration has begun. Thus, quiet expiration is not, as formerly thought, a wholly passive process. In forceful breathing, both external and internal intercostals are used. The transversus thoracis, latissimus dorsi, rectus abdominis, and external oblique are also used in expiration.

For speech, singing, and playing a wind instrument, tracheal pressure which produces the quality of sound and regulates the control of air flow is produced by the thoracic muscles and external and internal intercostals. The latissimus dorsi and rectus abdominis are brought in to help keep up the pressure. In most people, during speech, the diaphragm shows little activity; and expiratory control depends on coordination between the external and internal intercostals.

The laryngeal muscles, as well as the internal intercostals, are used in regulating the pitch of a voice in the adjustments in speech and in enabling stresses to be made. The external intercostals exert a check action after a stressed syllable and thus momentarily oppose the outward air flow induced by the internal intercostals. At a fairly regular interval after internal intercostals activity begins, tracheal pressure increases and it is then that sound follows.

Abstracters for January

We are indebted to the following Association members for the carefully prepared abstracts that appear in this issue:

Rachel Adams	Mary Jane Hayes
Mary Bennett	Nanette Keegan
Margaret Bryce	Dorothy Kemske
Betty Calabrese	Geraldine Midgley
Jean Cuthbertson	Patricia Wakefield
Joan Erback	Nancy Watts

We regret that through error the names of the following abstracters were omitted in the December issue of the *Review:*

Rachel Adams	Florence Murley
Elizabeth Davies	Patricia Wakefield
Nanette Keegan	Mary Wallace
Dorothy Kemske	Nancy Watts
Meredith Nordschow	

Book Reviews . . .

Back Pain: Diagnosis and Treatment Using Manipulative Techniques. By John McM. Mennell, M.D., Special Lecturer, Department of Physical Medicine, Medical School, College of Medical Evangelists, Los Angeles, California. Cloth, illus., 226 pp. Boston: Little, Brown and Company, 1960. $9.50.

A book in which the name Mennell appears as the author will arouse the interest of any well-informed physical therapist. The author states in the preface that he appreciates the difficulty of following in the footsteps of his famous father, the late James Beaver Mennell, M.D., of London, yet he is reassured by the fact that most of the concepts and findings of his father's practice have been tested and remain valid today.

The author hopes this work will help to clarify the status of joint manipulation in the treatment of pain arising from synovial joints. He recognizes the prevalence of back pain and it is with "the hope of bringing more certain alleviation to these patients" that he undertakes to present to the medical profession the methods of diagnosis and of treatment by manipulative technics which in his experience he has found to be valuable. He believes that this subject should receive more attention in medical schools and in postgraduate programs than is given at the present time.

This volume includes a Preface with acknowledgement to those who have assisted in its preparation and a Preamble in which the author briefly discusses the history of theories, which have existed in the past fifty years, regarding the various methods of treatment of back pain. He also emphasizes the importance of careful, detailed examination and diagnosis before following any routine method of treatment. The first section is entitled "Movement—Dysfunction—Manipulation—Spinal Movement." In this section the use of these terms throughout the book is explained and the author's term "joint play" is defined. Precise and detailed routine of history taking and examination are given in the following sections, namely: "The Low Back," "The Thoracic Spine," and "The Cervical Spine." Next follows the section entitled "Therapeutic Manipulation," which is discussed in detail and regarding which the author states, "No one should attempt until he is perfectly facile in his ability to put a normal joint through its normal range of movement; this means practicing on a normal subject." The remaining chapters of the book are "Prophylactic Treatment Against Joint Dysfunction in the Spine Conditions Coexisting with Dysfunction," "The Intervertebral Disc," "Arthritis," and "Whiplash Injury."

The photographs and line drawings used throughout this volume are well done and the legends are clear and concise.

Although Dr. Mennell's chief purpose in writing this book is to bring his methods of treatment by manipulation technics to the attention of the medical profession, he also recognizes the value of supplementing this by the use of other physical treatment. This makes this book of interest to physical therapists. He also advises the medical profession to make use of trained physical therapists and also to learn when and how to prescribe physical therapy when it is necessary.

The Utrecht Symposium on the Innervation of Muscle. (Held at the University of Utrecht, The Netherlands, July 17–20, 1957.) Edited by H. D. Bouman, M.D., Professor of Physical Medicine, University of Wisconsin; and A.L. Woolf, M.D., Consultant Pathologist, Midland Center for Neurosurgery, Smethwick, England. Cloth, illus., 223 pp. Baltimore: Williams & Wilkins Co., 1960. $5.00.

This symposium consists of twenty-two papers by twenty-six contributors presented at the University of Utrecht in 1957. All the subject matter in this publication originally appeared in Volumes 38 and 39 of the *American Journal of Physical Medicine*. The papers are based on clinical and experimental work of the authors rather than on summaries and reviews of the literature. Each contributor represents an outstanding laboratory or clinic from one of eleven different countries.

In the discussion of the innervation of muscle, the motor unit ("the individual nerve fiber with the bunch of muscle fibers it activates"), is described from the standpoint of the ratio of muscle fibers to nerve, and the number of motor units per muscle. Facts about the ultrastructure of the motor end-plate and the neuromuscular bundle are presented in an article on electron microscopy.

Other articles correlate biopsy results with electromyograms in various diseases affecting structural areas of the motor unit—myopathies, neuropathies, and myasthenia gravis. Similar studies, primarily in animals, correlate the electromyograms in innervated and partially denervated states. The effects of acetylcholine on the motor end-plate and its role in neuromuscular transmission, as well as the role of neuromuscular blocking drugs, are discussed.

To complete the description, the biochemical changes and the metabolic reactions of denervated and reinnervated muscles are presented. Thus, a comprehensive survey of the functional unit of the neuromuscular system in health and disease is brought together in one volume.

A certain amount of duplication is present. This, however, is welcomed because of the highly scientific nature and treatment of the subject. Each paper is well written with its own historical review, bibliography, and illustrative material. There are several electromyographic recordings with accompanying explanations.

This profound book may be recommended for the reference library of researchers, neurophysiologists, and physiatrists interested in electromyography.

Outline of Orthopaedics, Ed. 3. By John Crawford Adams, M.D., F.R.C.S. (England), Orthopaedic Surgeon, St. Mary's Hospital, London. Cloth, illus., 440 pp. Baltimore: Williams & Wilkins Company, 1960. $8.00.

This is the third edition of this volume, appearing at two-year intervals, and designed primarily as a text book or reference.

One of the outstanding features of this British publication is the emphasis and attention focused throughout its pages on the methods of clinical evaluation. Much of it is detailed to some degree, but it encompasses all aspects and facets of diagnostic procedure.

There is a general survey of ortho-

pedic conditions, problems and disorders, (with the exception of fractures) in 100 pages. It is felt that this is too broad a subject to be covered even lightly, in this space, particularly when it includes peripheral nerve injuries, cerebral palsy, poliomyelitis, endocrine pathology, and benign and malignant bone tumors.

In the remaining seven chapters disabilities are divided anatomically and discussed more fully and in greater detail, with specific conditions being considered from three phases. First, the predisposing cause, underlying pathology if known, or probable etiology; second, clinical features, and here again the author emphasizes the importance of history and physical findings in making a differential diagnosis and the investigation of possible referred symptoms. This is followed by a very brief discussion of treatment. Physical therapy is very rarely recommended as a treatment of choice, which is rather unusual. Instead, chemotherapy and surgery are most often suggested. More elaboration on this phase would have been valuable to the average person, especially in the allied fields.

Generally, the material covered is too comprehensive, although a full discussion in brief space is a part of the author's purpose. It is questionable how much of it comes within the true realm of orthopedics, particularly, for example, reflection upon six of the arthritides. However, the rare and uncommon conditions have been omitted and descriptions of surgical procedures minimized.

There are no cross references, no outside references, and no bibliography.

The illustrations are good, particularly the reproduction of roentgenograms, as are the two early woodblock prints in the Introduction.

This book would be quite helpful to an individual with a limited source of referral, but would be repetitious and inadequate if other reference material were readily available.

Parkinson's Disease: Its Meaning and Management. By Lewis J. Doshay, M.D., Ph.D., College of Physicians and Surgeons, Columbia University, New York. Paper, illus., 224 pp. Philadelphia: J. B. Lippincott Company, 1960. $1.45.

Written by the director of the Parkinson Research Laboratory at Columbia-Presbyterian Medical Center, New York, *Parkinson's Disease: Its Meaning and Management* is a handbook for the layman, primarily directed to the Parkinson patient and his family, although anyone having contact with the chronically ill would profit by a review of the content. Factual and forthright throughout, the text tends to be somewhat repetitious, perhaps with purpose; and it may be excused for an undisguised appeal to support the research program.

It deals clearly and honestly with the manifestations of the disease, naming three types: idiopathic, postencephalitic, and arteriosclerotic, and mentions associated complications of each type. A brief history of the misnamed "Shaking Palsy" and earlier methods of treatment, defeated largely by the attitude of hopelessness, is followed by the major content of the book: a more positive, albeit conservative, approach today through faithful attention to medication and rehabilitation programs.

Dr. Doshay surveys the effectiveness of a lengthy list of medications and some of the undesirable side-effects, hopeful of a drug to reverse the disease processes. A program of "Physiotherapy" is outlined to maintain or regain strength and mobility, ambulation and self-care.

In a discussion of various surgical and radiological procedures, it is the author's opinion that while immediate, gratifying results have been obtained in some of the more recalcitrant cases, the long range amelioration of symptoms has yet to be determined through more study and experimentation.

Arthritis and Allied Conditions: A Textbook of Rheumatology, Ed. 6. Edited by Joseph Lee Hollander, M.D., Associate Professor of Medicine, University of Pennsylvania School of Medicine. Cloth, Illus., 1306 pp. Philadelphia: Lea & Febiger, 1960. $20.00.

The first edition of this comprehensive textbook of rheumatology was published by the late Dr. Bernard I. Comroe in 1940. This latest edition is edited by Dr. Comroe's successor at the University of Pennsylvania, Dr. Joseph Lee Hollander, an Associate Professor of Medicine and Chief of the Division of Rheumatology at that school.

Part I thoroughly discusses the rheumatic diseases and provides a basic orientation for the reader as he progresses into the subsequent sections which deal more specifically with the etiology and clinical aspects of arthritis. The precise presentation of the etiology, pathology, and clinical picture of rheumatoid arthritis in Part II are readily understood and followed. There is an extremely interesting discussion of the rheumatoid factor as an important diagnostic aid and of the rheumatic cardiac lesions of arthritis.

Part III deals with the treatment of arthritis from both the clinical and orthopedic standpoints. The various medications used in treatment of arthritis are discussed separately in respect to both the desired and undesired factors resulting when each is used. Of special interest to the physical therapist are the chapters dealing with the orthopedic management of rheumatoid arthritis. Specific therapeutic exercise routines and positioning are discussed at some length; these would be applicable not only to the arthritic patient but to other types of chronically ill patients.

Part IV, in presenting factors which might influence the onset or course of rheumatoid arthritis, reviews some important psychological considerations in rheumatoid conditions. Special attention is given to the effect that any consideration of psychogenic disturbances in rheumatoid arthritis must include not only their role as exciting and aggravating factors, but also the serious emotional problems that may develop as a result of the disease process itself.

Part V provides very comprehensive material on the rheumatic diseases resembling rheumatoid arthritis: namely, spondylitis, psoriatic arthritis, hydrarthrosis, and the fibrositis syndrome. Other sections present excellent discussions on osteoarthritis, gout, and the metabolic bone and joint diseases.

The content organization and presentation in this textbook were well planned and systematically took the reviewer through the 71 chapters so that each chapter integrated with another which made for fast and effective reading. The book brought the reader abreast of the new developments and methods of treatment in the field of rheumatology. Illustrations, x-rays, cross-sections of tissue, and charts and graphs were effectively incorporated into the book contents which make much of the technical information easier to understand.

Despite the wealth of study and

information presented, the readability of the book renders it not too technical for individuals in the auxiliary medical fields. This book would make an excellent and useful reference book in any physical medicine department engaged in work with the arthritic patient.

The Natural History of Cerebral Palsy. By Bronson Crothers, M.D., Senior Consultant in Neurology, Children's Medical Center, Boston; and Richmond S. Paine, M.D., Associate Physician in Neurology, Children's Medical Center, Boston. Cloth, Illus., 285 pp. Cambridge, Mass.: Harvard University Press, 1959. $6.75.

The Natural History of Cerebral Palsy presents a thought-provoking account of the management of a series of cerebral palsied individuals.

Each of the 1,821 cerebral palsy patients was seen by one of the authors during the period of 1930–1950. Of the total number of these cases, 655 were reexamined by the authors; 746 were successfully followed up by letter; and 420 were written to but did not respond. The information gained from long-term records, follow-up, and reexamination, provide material which will be the basis for many discussions. The authors present with clarity their idea of the "core" of the problem with the hope that their findings will be as disconcerting to the readers as it has been to them.

A wide range of subject matter is covered with clarity and conciseness. Especial emphasis is given to the effects of *growth* and *development* on the evaluation of results from treatment and the importance of the often overlooked emotional status of the cerebral palsied individual. The authors point out sharply the need for periodic examination and reevaluation of the management of the child at the ages of six, twelve, and at the end of adolescence.

The incidence of seizures among patients with cerebral palsy is ably presented and accompanied by informative charts and graphs. The authors stress the need for individual evaluation of each patient, a point especially brought out in the chapter dealing with the interpretation of the patient's intellectual potential. The importance of evaluating all the findings on each individual case in regard to employability is also stressed; and excellent charts are included in the section, "Life Expectancy and Employability."

The section, "Treatment of Motor Disabilities," is of outstanding value. To therapists and other medical personnel dealing with this particular group of handicapped indivduals, it is important that the *long-term* follow-up care enabled the authors to draw conclusions with greater authority than reports on short-term follow-up care. It may come as a shock to the reader to learn that the authors feel that the influence of *growth* and *development* and the attitude of the individuals dealing with cerebral palsied patients are usually more important than technics of treatment.

The authors emphasize that the emotional and intellectual problems are just as important as the physical problems, if not more important. The dangers of undue pressure, overoptimism or defeatism are brought out through case histories. The remarkable display of "fruitful ingenuity" of parents and patients is cited. One of the finest chapters, according to this reviewer, is the one entitled "Emotional Status." Here, the authors share their vast knowledge of the subject with the readers, through a series of 23 excellent case histories.

The tremendous influence of *growth* and *development* is brought out sharply in this chapter. The authors stress the need to differentiate between psychologic and physical impairment. It is of great interest to note that the authors have become more keenly aware, through this study, that most of the successful individuals have rebelled, at some time or other, against their advisors. Although affection and confidence are vital to the cerebral palsied, they must be permitted to make their own experiments and, at times, their own decisions. The authors warn medical personnel against the danger of pride in the physical accomplishments made by the child while the more important emotional problems remain unrecognized.

The one important conclusion reached by the authors in this survey will stimulate physical therapists to reevaluate their treatment and management program for cerebral palsied patients. The conclusion can be stated simply. Damage or abnormality of structure occurs early in life and disturbs function. The effects of this disability on *growth* and *development* must be given more serious consideration if the patient is to attain his maximum achievement in adult life.

The Natural History of Cerebral Palsy is printed in clear type on non-glossy paper. The style of writing is easy to read and the authors manage to identify themselves with the reader by conveying the fact that they too are still searching for answers.

The book contains many excellent photographs and valuable graphs and tables. One-half of the book contains "Classification of Cerebral Palsies," "Etiology and Pathology," and a description of the different types of cerebral palsy. One-quarter of the book is entitled "Emotional Status in Adolescence and Early Adult Life" and "Effect on The Family."

This book differs from others in the field because it is the *first* critical analysis of the results of a *long-term* follow-up of cerebral palsied cases. Evaluation of the various types of management has been presented in a manner which enables the reader to evaluate the literature in the field of cerebral palsy with deeper insight.

The Child in Hospital. By Hedley G. Dimock, Ph.D., Coordinator of Staff Development and Training, Montreal, Y.M.C.A. Cloth, 326 pp. Philadelphia: F. A. Davis Company, 1960. $4.50.

This book is apparently addressed to students rather than to experienced professional people. The style is very simple and direct with many brief didactic statements and a minimum of discussion. There is a subject index and an extensive bibliography.

The subject matter deals chiefly with children who are hospitalized for a comparatively long time, though well enough to participate in group education and recreation, and able to benefit by guidance and counseling programs, and to experience hospital life as a social experience. In this respect students of physical and occupational therapy would find the book of value. It is also appropriate for student nurses, teachers, and others who are engaged in group work.

The title is somewhat misleading because it does not indicate the emphasis upon participation in group activities. There is very little mention of the individual problems of the child who suddenly finds

himself, incapacitated by illness or injury, away from home in an unfamiliar environment, and required to experience many changes from his normal daily life, including some which are painful and frightening. It would seem proper under the title to include more suggestions to help parents and the hospital staff to understand the unspoken feelings and smothering apprehensions of these young and acutely ill children who need self-confidence, quiet amusement, and willing tolerance of unpleasant procedures and restrictions.

Physics and Electronics in Physical Medicine. By A. Nightingale, M.A., Ph.D., Senior Lecturer and Chief Physicist, St. Thomas Hospital, London. Cloth, illus., 292 pp. New York: The Macmillan Company, 1960. $6.00.

This is a textbook written primarily for those preparing for Part I of the Diploma in Physical Medicine. However, it will serve well for those in medicine who have need or desire to brush up on basic physics.

Dr. Nightingale has written this book so that those in medicine and related fields would not be required to retake basic courses in physics before their professional examinations. He sympathizes with those who have found the subject difficult, and he has, as the Foreword by Dr. F. S. Cooksey states, taken great pains to produce a text which is lucid, well-illustrated by example and diagram, succinct yet in sufficient detail, and a pleasure to read.

Part I deals with the fundamentals of physics and is a good review for anyone who has studied the subject, but comprehensive enough for those who have not had college physics or who have had a difficult time in it. The things stressed, of course, are those most used in physical medicine. Each chapter has its own summary.

Part II deals with the applications of the principles in Part I. This is a survey of the physiological effects of electricity and its use in physical medicine. It is divided into five short but concise sections: 1. Direct currents: electrolytic effects; 2. Low-frequency alternating and pulsed curents: stimulating effects; 3. High-frequency currents: heating effects; 4. Microwave radiation: heating effects; and 5. The effects of physical factors and the physiologic responses on the rise in temperature of the tissues.

Part III consists of Appendices that are most useful and informative. These are:

1. Some Useful Mathematical Techniques.
2. The Use of Vector Diagrams in Analyzing A. C. Circuits.
3. The Cathode Ray Oscilloscope.
4. Electromyography.
5. 'Constant Current' and 'Constant Voltage' Stimulaters.
6. Microwave Diathermy.
7. Ultrasonic Therapy.
8. Transistors.

The book has very clear diagrams throughout which are numbered as to chapters. There is a comprehensive bibliography, as well as an index, for quick reference.

This book is one that fills a need for many physical therapists and should be very useful in their private libraries as well as the libraries in hospitals and schools of physical therapy. It is written in an interesting and informative style and is actually a textbook that is a pleasure to read. Of particular interest is the appendix on mathematics. This gives a quick and effective review for the mathematics in physics which is often forgotten and without which you cannot understand physics.

Functional Anatomy of the Limbs and Back. Ed. 2. By Henry Hollinshead, Ph.D., Head, Section of Anatomy, Mayo Clinic, Rochester; Professor of Anatomy, Mayo Foundation, University of Minnesota. Cloth, illus., 403 pp. Philadelphia: W. B. Saunders, 1960. $9.00.

The subtitle—*A Text for Students of Physical Therapy and Others Interested in the Locomotor Apparatus*—indicates very clearly that this is a text written especially for the student of physical therapy. In this second edition the author has maintained his orignal purpose and provided a readable account of functional anatomy in terms that a beginning student can comprehend. The five-section presentation has been maintained, with more detailed material given in the sections on the limbs. Brief reviews on the more pertinent material have been added, as well as tables of nerves and muscles, and a number of figures showing vessels and nerves. The new figures on vessels and nerves have been taken mainly from a larger publication by Dr. Hollinshead *(Anatomy for Surgeons)*.

That this text has stood the test of usage is probably in so small part due to the fact that the author published the original text only after the usage of the material, in mimeographed form, in his classes of anatomy for physical therapy students. This contact with the needs of the physical therapy student has been maintained throughout the revision through the cooperation of physical therapy instructors using the text.

The index gives indication of inclusion of material not appearing in the first edition on topics pertinent to the future physical therapist: e.g., clubfoot, effect of exercise, fatigue of muscles, footdrop, kyphosis, motor unit, substitution or "trick" movement, scoliosis, torticollis, winging of scapula, and others.

Nomina Anatomica, 1955, was used throughout, with synonyms given when it was felt by the author that a student would be handicapped without the knowledge of a commonly employed term. A list of synonyms is also included.

No references are given nor is there a bibliography.

This book should continue to be useful not only to the physical therapy student, but to all physical therapists and others interested in human anatomy.

Arthritis: Medical Treatment and Home Care. By John H. Bland, M.D., Director of the Clinic for Rheumatic Disease at Mary Fletcher Hospital, Burlington, Vermont. Cloth, illus., 208 pp. New York: Macmillan Company, 1960. $4.50.

This monograph, by a physician with wide experience in the field of rheumatology, was written specifically for the arthritis patient, his family, and his physician. Dr. Bland's purpose in writing the book was to provide each of these groups with knowledge regarding the nature and characteristics of the disease itself, the concepts, and technics of succesful treatment.

It is pointed out that arthritis is the most ancient disease of man and animal. Only in the last few years, however, has the magnitude of the problem been appreciated. Despite research and study, the

cause and cure of arthritis are as yet unknown. Even though there is no cure as such today, it is stressed repeatedly that a comprehensive home-care program leads to increased ability and decreased disability.

The appendix contains a very short section on self-help devices and it lists the major organizations devoted to education, research, and treatment, also clinics that specialize in the treatment of arthritis. A glossary and an index are included. There is no bibliography, as such, but there are seven footnote references.

Throughout the book, the importance of heat, massage, and an individualized regimen of rest and exercise is repeatedly emphasized. In the chapter devoted to physical therapy, specific instructions in the home application of physical therapy procedures are presented.

The format is logical and the type clear; most of the illustrations are good, but two or three are of questionable value inasmuch as they relate to positioning for prevention of deformity.

The monograph is written in lay terms and should serve well its stated purpose of supplying to the arthritis patient and his family information regarding the nature and treatment of his disease. As a reference book for the physical therapist or the student, however, it is too general in scope to be of much use.

Clinical Management of Behavior Disorders in Children. Ed. 2. By Harry Bakwin, M.D., Professor of Clinical Pediatrics, New York University; Visiting Physician, Bellevue Hospital; Attending Pediatrician, University Hospital; and Ruth Morris Bakwin, M.D., Associate Professor of Clinical Pediatrics, New York University. Cloth, illus., 597 pp. Philadelphia: W. B. Saunders Company, 1960. $11.00.

Clinical Management of Behavior Disorders in Children is a textbook designed to guide medical students and young practitioners as they endeavor to perfect the science and art of diagnosis and prescription.

Both of the authors are qualified by preparation, experience, knowledge, and interest to sort out significant and useful information from the vast amount of material which has been published on the management of behavior disorders in children. This objective they have achieved successfully. The inexperienced pediatrician and psychiatrist and those concerned with child guidance programs should find the book helpful because of its factual summarization of the findings and conclusions of recognized researchers and clinicians who have studied and treated both normal and exceptional children over the years.

One does not find a fresh approach to any of the subjects dealt with in the text, nor is there convincing evidence that the authors had any objective other than a painstaking recording and systematic, clear presentation of the discoveries and suggestions of many physicians and investigators in pediatrics and allied fields. Practically every topic related to the psychologic and emotional aspects of a child's life which has excited the curiosity of professional personnel is presented; but the subject matter is frequently handled superficially in the area of management of the child.

The format of the text follows an accepted conventional pattern. The type is of good quality as is the paper. The illustrations are few and not striking in nature.

The accuracy of the author index, subject index, and bibliographies confirms the impression that methodical care and a great deal of time were expended on the text. As a result, the Bakwins have compiled an excellent bibliographic source book which is a ready reference if one wishes to gain an acquaintance with various behavior disorders in children and a superficial survey of the field of clinical management.

Original concepts of management, proof of depth of understanding of the presenting problems, and sufficient practical examples of clinical management are lacking to the extent that the more discerning student and the more experienced individual would consider the book elementary.

The reviews published here do not necessarily represent the opinions of the American Physical Therapy Association.

Book Reviewers for January

Gertrude Beard, Physical Therapist, Bethany Hospital, Kansas City, Kansas.

Beryl B. Bilderback, inactive member of the Association; formerly Instructor, School of Auxiliary Medical Services, University of Pennsylvania; more recently, affiliated with the Wisconsin Neurological Foundation.

Edna M. Blumenthal, Former Director of Rehabilitation, The North Carolina Cerebral Palsy Hospital, Durham, North Carolina.

Virginia L. Frost, Chief, Physical Therapy Section, U.S. Army Hospital, Fort Sill, Oklahoma.

Louise R. Hewson, Chief Clinical Psychologist, Neurological Institute, New York.

Gloria Hirschberger, Physical Therapist, Jeannette Memorial Hospital, Jeannette, Pennsylvania.

Deborah Kinsman, Assistant Director, Physical Therapy Department, Vanderbilt University Hospital, Nashville, Tennessee.

Catherine McClure, R.N., Ph.D., Associate Professor, University of Pittsburgh, Pennsylvania.

William J. Shriber, M.D., Chief, Physical Medicine, Beth Israel Hospital, Boston; Associate in Medicine, Harvard Medical School, Boston

Mrs. Julienne C. Steffens, Physical Therapist, Glastonbury, Connecticut.

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New items which may be of interest to physical therapists will be mentioned in these pages each month. The accompanying explanations are made by the manufacturers and have not been investigated by the *Physical Therapy Review*.

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Positions Available as STAFF PHYSICAL THERAPIST. Salary range $4,800-$5,600. Starting salary based on experience. Merit increases, 40-hour week, 3 weeks vacation, holidays, sick leave, health and life insurance and retirement plans available. Affiliated with Wayne State Univ. Medical School and developing P.T. School. Comprehensive rehabilitation program for inpatients and outpatients and P.T. for 650-bed general hospital. Graduates of approved schools of P.T. and should hold membership in APTA and/or Registry. Contact Mr. John C. Bay, Administrator, Rehabilitation Institute of Metropolitan Detroit, 261 Brady, Detroit 1, Mich.

QUALIFIED PHYSICAL THERAPISTS wanted to serve in 1000-bed, modern hospital for the long-term ill, affiliated with the University of Cincinnati. Physical Medicine Department, well-equipped with modern equipment in all modalities; under direction of physiatrist, P.T., O.T., and A.D.L. sections, in expanding Rehabilitation Program dealing with complete cross-section of medical and surgical problems: arthritis, brain injuries (traumatic, surgical, vascular), cord injuries, neurological disorders, orthopedics, general surgery. Starting salary to $4609.92 with yearly increments. Liberal fringe benefits—8:00 A.M. to 4:00 P.M., 40-hour week; lunch; laundry; paid statutory holidays (10); sick leave (15 days); pension plan; University City on the Ohio River. Apply to Morris L. Stein, M.D., Director, Physical Medicine and Rehabilitation Department, Daniel Drake Memorial Home and Hospital, Galbraith Road, Cincinnati 16, Ohio.

PHYSICAL THERAPIST WANTED

Position available for an experienced physical therapist to act as consultant to Central Ohio Hospitals and Rest Homes, in the convalescent care of the hemiplegic patient. Must be an RPT, plus two years general experience and own automobile. Good salary, plus travel expenses. Central Ohio Heart Association, 145 North High Street, Columbus 15, Ohio.

WANTED: PHYSICAL THERAPIST for 200-bed general hospital, semi-closed staff. Physicians, referring patients, all board certified or eligible. Salary open; Christmas bonus; paid vacation; sick leave; holidays; good housing available; expenses paid. Applicants invited for personal interview. Contact Wayne B. Foster, Adm., Holzer Hospital & Clinic, Gallipolis, Ohio.

STAFF PHYSICAL THERAPIST: Position available. Salary range $4525-$4975. Starting salary based on experience. Merit increases, 37½-hour week, vacations, holidays, sick leave. Well-equipped department. Affiliated with Northwestern University Medical School. P.T. student training program. Comprehensive rehabilitation program for in-patients and out-patients. 70-bed hospital. Congenial atmosphere. Excellent opportunity for personal development. Should be graduate of approved school of P.T. and hold membership in APTA or Registry. Contact Miss Hildegard Myers, RPT, Rehabilitation Institute of Chicago, 401 E. Ohio St., Chicago 11, Ill.

REGISTERED PHYSICAL THERAPIST for well-equipped department in 425-bed general hospital, located in pleasant, residential, lake-shore suburb of Chicago. Good salary, 40-hour week, progressive personnel policies. Apply: Personnel Office, Evanston Hospital, 2650 Ridge Avenue, Evanston, Ill.

PHYSICAL THERAPIST—$5828-$6368 per year, subject to legislative concurrence. For 500-bed suburban Detroit hospital moving into modern new building in 1961. Up to 15 days vacation, 11 holidays, other liberal fringe benefits. Must have completed APTA approved training. Contact: Wayne County Civil Service Commission, 628 City-County Building, Detroit 26, Mich.

INTERESTING CAREER POSITION acting as Director of a physical therapy program in a convalescent hospital. Salary $5100-$5400 to start, merit increases to $6000. Graduation from accredited college or university with specialization in physical education or nursing, and completion of an approved course in physical therapy required. Five-day work week; paid annual leave and sick leave plans; retirement plan combined with Social Security; life insurance and hospitalization benefits. Apply: Personnel Office, Oakland Office Building, 1 Lafayette Street, Pontiac, Mich., FE 3-7861.

POSITION AVAILABLE as Staff Physical Therapist to test brain-damaged children in school for mentally retarded. Challenging position with opportunity to attend graduate school at Ohio State University. Must be eligible for state licensing. Contact Dr. Ernest Johnson, Physical Medicine, Columbus State School, 1601 West Broad Street, Columbus, Ohio.

EXPERIENCED PHYSICAL THERAPIST: To carry small case load and give consultant services to nursing staff. Salary range $5500-$7500. Contact Visiting Nurse Assoc., 1206 N. Astor, Milwaukee 2, Wis.

WANTED—Staff physical therapist for outpatient center with a general rehabilitation program. Excellent facilities and equipment. Starting salary, no experience needed, $4500 per annum. Three weeks paid vacation and sick leave. 40-hour, 5-day week. For further information write G. Margaret Gleave, Executive Director, The CURATIVE WORKSHOP of Racine, 2335 Northwestern Ave., Racine, Wis.

Positions Available

E. NORTH CENTRAL (con't)

IMMEDIATE OPENING for a registered physical therapist to work in hospital's well-equipped physical therapy department. Of special interest: variety of cases and closely knit team approach with medical staff, liberal personnel policies, salary commensurate with experience. Contact Glenn C. Williams, Administrator, Mary Free Bed Guild Children's Hospital & Orthopedic Center, 920 Cherry Street, S.E., Grand Rapids 6, Mich.

EAST SOUTH CENTRAL

REG. PHYSICAL THERAPIST: New air-conditioned C. P. outpatient clinic supervised by physiatrist; 40-hr. 5-day wk.; 3-wk. rest period; 13 holidays. Starting salary for inexp. therapist $4,200. Write Adm. Les Passees Center, 49 N. Dunlap, Memphis, Tenn.

WEST SOUTH CENTRAL

OPENING FOR EXPERIENCED registered physical therapist (female) Sept. 15th in private Orthopedic Clinic. Salary $400 per month plus yearly bonus. 35-hr. week. Two weeks paid vacation. Contact Graybill-Wilson Orthopedic Clinic, 1202 Arlington, Lawton, Okla.

IMMEDIATE STAFF OPENINGS for 2 Male Registered Physical Therapists. Starting salary $450 monthly. 5-day week. 100-bed special hospital for arthritis. For further information write: E. K. Clardy, M.D., Leo N. Levi Memorial Hospital, P.O. Box 850, Hot Springs, Ark.

URGENTLY NEED qualified physical therapists for inpatient and outpatient services. Under university auspices. La. Chapter, Arthritis & Rheumatism Foundation. 1430 Tulane Ave., New Orleans 12, La.

WANTED Immediately. Physical Therapist staff position Crippled Children's Hospital treating primarily cerebral palsy and polio with some adults. Salary range $350-$400 starting, depending on experience; 37½ hour week, 6 paid holidays, two weeks vacation after six months, noon meal and laundry of uniforms gratis. Contact Administrator, Crippled Children's Hospital, 1316 Third, Corpus Christi, Texas.

WANTED IMMEDIATELY: Registered, physical therapist (male or female) for expanding orthopedic clinic. Will consider recent graduate. Good starting salary. Apply: Mrs. J. Cowl, Director, Laredo Rehabilitation Center, 400 Arkansas, Laredo, Texas.

MOUNTAIN

REGISTERED PHYSICAL THERAPIST (woman) for out-patient New Mexico Rehabilitation Center Inc. Immediate opening; 5-day week, paid vacation and sick leave. Social Security. Salary in keeping with experience. For details write to Arthur Osterholm, 1023 Stanford Drive NE, Albuquerque, New Mexico.

PACIFIC

TWO (2) CALIFORNIA REGISTERED Physical Therapists wanted for our Physically Handicapped Childrens' Schools. Salary $444-$515. Full Civil Service benefits, including vacations, sick leave and liberal retirement plan. Apply: Sacramento County Civil Service Commission, Court House, Sacramento, Calif.

ORTHOPAEDIC HOSPITAL & REHABILITATION CENTER: Large enough for extensive service and teaching programs; small enough for close working relationship with medical, nursing, psychologic and other staff. Research opportunities. Treatments include amputees, spinal cord injuries, cerebral palsy, acute and reconstructive polio, arthritis, congenital defects. Good salary and benefits. Write: Director, Department of Physical Therapy, Orthopaedic Hospital, 2400 South Flower Street, Los Angeles 7, Calif.

GRADUATES OF APPROVED SCHOOLS FOR PHYSICAL THERAPISTS: You may now practice under professional supervision in this State pending registration with the California Board of Medical Examiners. Positions open in State Hospitals, the Veterans Home, and special schools for handicapped children. Starting salary $458, higher in some locations; liberal employee benefits; promotional opportunities. Streamlined civil service examinations twice a month in San Francisco and Los Angeles, and on request in other states near candidate's residence. Write: State Personnel Board, 801 Capitol Avenue, PT 71, Sacramento 14, Calif.

CALIFORNIA OPPORTUNITY

Physical Therapist in new San Luis Obispo County General Hospital. Full range of therapy. "Other State registrants employable provisionally," pending California registration. Salary range: $419-$505. Starting salary based on experience. Write County Civil Service Office, 967 Osos Street, San Luis Obispo.

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Positions Available

PACIFIC (con't)

STAFF PHYSICAL THERAPIST for 155-bed general hospital. College community, 30 minutes from San Francisco. Write details of education, experience, and references to: Miss Shirley J. Kelly, Chief Physical Therapist, Alta Bates Community Hospital, Berkeley 5, Calif.

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CRIPPLED CHILDREN'S SERVICES

Graduates—Approved schools for Physical Therapy. Positions open in special schools for handicapped children. Starting salary $507; liberal employee benefits. Temporary appointment pending California registration. Write Dept. Civil Service and Personnel, Rm. 403, Civic Center, San Diego, Calif.

TWO STAFF PHYSICAL THERAPISTS experienced—for Rehabilitation Center, Pacific Northwest. Five-day week, paid vacation, sick leave, retirement and Social Security benefits. Salary starts at $380 monthly, annual increases. New building and most modern equipment available. Splendid educational and recreational opportunities available. Write: Miss Lila Scott, Supervision Therapist, Department of Labor and Industries, Rehabilitation Center, 4730 32nd Ave. South, Seattle 8, Wash.

PHYSICAL THERAPY CONSULTANT for crippled children's program. Three years experience required, including one year at supervisory or teaching level. Salary range: $492-$586. Inquire: Personnel Officer, Washington State Department of Health, Smith Tower, Seattle, Wash.

PHYSICAL THERAPIST for Cerebral Palsy Program operated by the Santa Clara County Health Department in local School for physically handicapped children. Salary: $478–$581 per month, paid vacation, sick leave, retirement system and group health insurance plan. Apply to: Mr. Robert Reiman, Supervising Cerebral Palsy Therapist, 2220 Moorpark Avenue, San Jose 28, California.

STAFF PHYSICAL THERAPIST: Immediate opening in a private program offering preschool and therapy services to cerebral palsied children under 6. Affiliated with the University of Washington, Dept. Physical Medicine and Rehabilitation and other student program. Also under direction of an Orthopedist who is a member of the Academy of Cerebral Palsy. An opportunity to gain experience and knowledge of methods and treatment in the field of cerebral palsy. Month vacation; 35-hour week; plus extra time off at Christmas and Easter. Salary up to $4560 per annum, depending on experience and education. Contact Wilma Krans, Supervising Physical Therapist, Spastic Children's Clinic and Preschool, 1850 Boyer Ave., Seattle 2, Wash.

Index to Advertisers

The Birtcher Corporation 16
Burdick Corporation ..... third cover
Chattanooga Pharmacal Co., Inc. 3
C. D. Denison Orthopaedic Appliance Co. 9
Elgin Exercise Appliance Co. 3
Georgia Warm Springs Foundation 4
S. R. Gittens 9
Hill Laboratories 13
LaBerne Manufacturing Company 2
Leverage Hand Brake Co. 9
Medco Electronics Company, Inc. 7
J. A. Preston Corporation ..... second and fourth covers and pages 1 & 74
Rehabilitation Products (Div. American Hospital Supply Corp.) 11
Sierra Engineering Co. 15
Teca Corporation 4
The Walkaway 14

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